Investigating the Usage of Water of the Plant *Portuluca oleracea* in Drought

Extended Essay (Biology)

Supervisor: ŞİRİN GÜNTÜRKÜN

Candidates Name: RENGİN KOCAOĞLU

Candidates Number: D1129061

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Abstract

Drought is a dangerous problem for humanity and for nature that global warming causes. There are insufficient researches about how to minimize the repercussions of drought so a research question formed, which is: 'Is *Portulaca oleracea* effective at decreasing the consequences of global warming?' and an experiment decided to make to observe the validity of this question. *Portulaca oleracea* used in the experiment instead of another plant because it has long living periods at high temperatures and it can survive long times without having water. Control group for *Portulaca oleracea* is Spinacia *olecacea*. *Portulaca oleracea* is a C_4 plant, Spinacia *olecacea* is a C_3 plant. C_4 plants show remarkable adaptations to high temperatures and water stress. In the experiment three of the flowerpots contained *Portulaca* oleracea seeds where the other three flowerpots contained Spinacia *olecacea* seeds. The flowerpots watered with 0.1 kilograms of water daily until they became one week old. After the plants developed their leaves, 0.2 kilogram of water added to each of the flowerpot which made them to become 1.075 kilograms. The method of this experiment was equalizing the masses of the flowerpots to 1.075 kilograms with adding water by weighing them daily. The process made to find out the daily amount of consummated water by plants while doing their photosynthesis. All the flowerpots should be weighted every day to have a continuous data. This process made for 15 days. After finishing the experiment T-Test made to compare the two sets of data. As the results showed, t value was bigger than 3.6739 (4.3753>3.6739) which supported the hypothesis. So, *Portulaca oleracea* uses less water than Spinacia *olecacea*. Using *Portulaca oleracea* in droughty places can be a solution for both the water and nutrient problem.

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Introduction

The time I was researching for a topic for my extended essay, I was concerned about the effects of drought on the amount of photosynthesis done by plants. I heard there is no sufficient amount of water for humanity in future[1]. Nearly all the ecosystems had shifted because of global warming.[2] Global warming destructed some life forms; the Indian Ocean corals, had died in the unusually hot summer of 1999.[3] Global warming causes, green house effect which is just like a glass bowl around the world allows gas entry but no exit, this make the earth warmer. Green house effect has not only a harmful side, at the other hand without this warming; earth would be cold to live on. As drought become more and more important nowadays I decided to take the subject about the effects of drought on photosynthesis done by plants as my extended essay subject.

Algae and certain bacteria like cyanobacteria produce nearly half of the atmospheric oxygen. Also plants produce oxygen and help balance the level of carbon dioxide in the atmosphere.[4] But C_3 plants (rice, wheat and soybeans[5]) cannot survive in drought. C_3 plants cannot use water thrifty.[6] In drought water is very important, so plants have to use water thrifty and at the same time plants should do photosynthesis. C_4 plants can do photosynthesis at high temperatures and use water thrifty. The examples of C_4 plants are *Saccharum officinarum* (sugar cane), *Zea mays* (corn), *Portulaca oleracea* (purslane).[7] These types of plants can store the extra water for them to use later Plants show remarkable adaptations to high temperatures and water stress.[8]

[2] ÇEPEL, Prof. Dr. Necmettin Ekolojik Sorunlar ve Çözümleri
[3] GRAHAM, E. Linda
GRAHAM, James M.
WILCOX , Lee W. Plant Biology 'Global Warming; Too Much of a Good Thing'
[4] GRAHAM, E. Linda
GRAHAM, James M.
WILCOX , Lee W. Plant Biology 'Algea, Fungi and Lichens'
[5] CAMPBELL, Neil A.
REECE, Jane B. Biology
[6] BOZCUK, Prof. Dr. Suna, Bitki Fizyolojisi
[7] ÇEPEL, Prof. Dr. Necmettin Ekolojik Sorunlar ve Çözümleri
[8] ÇEPEL, Prof. Dr. Necmettin Ekolojik Sorunlar ve Çözümleri

These types of plants can store the extra water for them to use later and use only the enough amount of water. Plants show remarkable adaptations to high temperatures and water stress.[8] This made me to ask why we don't use them to survive other living things in case of there is no other plants exist on earth because of drought. C_4 plants can avoid the effects of drought in some cases. They can still do photosynthesis in high temperatures and still produce oxygen when other plants die. All C_4 plants like *Portulaca oleracea* have long living periods at high temperatures without having water. This is because of the well adaptations that C_4 plants had like hiding their stomata under thick cuticles also they do photosynthesis different from C_3 plants. This prevents loss of water.[9]

While there have been several studies about drought and how to avoid this, there is less knowledge as what should humanity do if there is a serious effect of drought in future. This could show what would happen after a drought come and its effects. For example sea level rises, snow cover and ice extent decreases. The risk of not finding enough water increases. Also enzymes and other proteins become unstable and organism dies; at higher environmental temperatures. And solar radiation can cause serious damages among species.[10] The reason why I chose the *Portulaca oleracea* is, *Portulaca oleracea* is a member of C_4 plants which shows adaptation for drought and doing photosynthesis at high temperatures like in the case of drought. It was the best to see how they use sufficient amount of water to live and how they could help humanity in future as the only source of oxygen gas and nutrient. By doing photosynthesis *Portulaca oleracea* can produce oxygen and at the same time it can be a food source. In contrast of the C_4 plants with C_3 plants, while C_4 plants can only do photosynthesis can be the source of oxygen and balancing of the carbon dioxide in the atmosphere, but at the other side the C_3 plants do photosynthesis in their optimum temperatures, not high temperatures as C_4 plants can do. I chose *Portulaca oleracea* instead of a cactus; because *Portulaca oleracea* has leaf that I can control leaf number while contrasting number of leaf with *Spinacia olecacea.* Also *Portulaca oleracea* has short life cycle, making it an optimal plant for short term investigations.

[9] BOZCUK, Prof. Dr. Suna, Bitki Fizyolojisi

[10] HARPER, John L.
TOWNSEND, Colin R.
BEGAN, Micheal. Essentials of Ecology 'Global Warming? Can We Risk it?'

But in contrast I chose *Spinacia olecacea,* a C_3 plant, to observe the usage of water differences between *Portulaca oleracea. Portulaca oleracea* and *Spinacia olecacea* both have nearly the same properties like number of germinating days, leaf structures and root types. Both can show remarkable changes due to the amount of water. Also they are consumable.

I chose to perform an experiment involving amount of water used by *Portulaca oleracea* during photosynthesis in drought in contrast with *Spinacia olecacea*. By contrasting them, the differences between a C4 and a C3 plant can be clearly seen. As a result, this paper will focus on the research question: **'Can *Portulaca oleracea* do photosynthesis with using less water in the case of drought rather than *Spinacia olecacea*?'** and will discuss how the experiment planned and performed.

Hypothesis

C_4 plants have a special anatomy which called Kranz Anatomy.[11] This specialized anatomy increases the rate of the photosynthesis in C_4 plants, rather than the rate of photosynthesis in C_3 plants. Extreme situations like lower concentrations of carbon dioxide, higher temperature, higher light intensity, drought and higher oxygen concentrations C_4 plants have more advantages than C_3 plants in doing photosynthesis. To the water stress C_4 plants are more resistant. Their stomata are closed nearly all the day to do respiration at minimum level. So the economic use of water can be done by C_4 plants. For this reason, effects of using C_4 plants are important for avoiding the unpleasant repercussions of drought.[12] C_3 and C_4 plants have differences in using different amount of water. Also this difference can cause huge variations on effects of drought.

It is expected that amount of used water will show the water need differences between *Portulaca oleracea* and *Spinacia olecacea* in drought. If *Spinacia olecacea* cannot find enough water, it will no longer do photosynthesis and die.[13] In the case of drought *Portulaca oleracea* can survive, continue to do photosynthesis and can obtain oxygen for humanity that will be needed in the future. Also it can be a source of nutrient. So *Portulaca oleracea* should be used in every region that is under threat of drought.

It can therefore be hypothesized that as *Portulaca oleracea* use less water than *Spinacia olecacea* in drought. At the end of the experiment, it is expected that *Portulaca oleracea* needs less water than *Spinacia olecacea* and this water usage difference will be observed by weighing them daily.

[11] BOZCUK, Prof. Dr. Suna, Bitki Fizyolojisi
[12] GRAHAM, E. Linda
GRAHAM, James M.
WILCOX , Lee W. Plant Biology
[13] GRAHAM, E. Linda
GRAHAM, James M.
WILCOX , Lee W. Plant Biology

Method Development and Planning

Planning an appropriate method to support or reject the present hypothesis conveyed lots of problems with it. First problem was how to gain numerical data during the experiment. The amount of gas which excesses could not be measured, so the solution of this problem was to find another way to prove the effects of C4 plant, *Portuluca oleracea*, for evading the unpleasant consequences of Global Warming. Without being able to verify this accurately, the quantitative examine of the numbers of the leaf was not the best solution for this problem. After further research and interviewing with a professor[14] in Faculty of Agriculture the problem could finally be solved using the technique by weighing the mass of the growing plant, Portuluca *oleracea*, and the mass of the control plant, *Spinacia olecacea*. The aim of weighing the *Portuluca oleracea* and *Spinacia olecacea* is to observe the amount of water that is used during the one day period of photosynthesis with respect to the increasing weight of the synthesized materials by the plant.

Another problem was how to be sure that all variables were being controlled. To build the best method and arrange all the variables for the experiment, I get help from the professor, Prof. Dr. İlhan Karaçal in Faculty of Agriculture. Prof. Dr. İlhan Karaçal gave me the idea to weigh the flowerpots daily to compare the amount of water used by the plants in one day period. Light intensity, temperature and the amount of the water were the most important variables for this experiment. Also type of soil, amount and kind of minerals should be taken under control. The kind of the C4 plant, *Portuluca oleracea*, should carry nearly the same properties as the control plant has. This was important for contrasting them in every way. For this reason I choose to use *Spinacia olecacea. Spinacia olecacea* uses more water than *Portuluca oleracea*.[15] But they are more or less the same because their numbers of days of germination are nearly the same, they have eudicot characteristics, same root and venation structure[16] except the amount of water they use and being a C4 and a C3 plant. The environment where the experiment took place in should be the same for both control and experimental groups. In addition for setting a drought environment, a glass lantern should be used.

[14] Karaçal, Prof. Dr. İlhan

[15] Karaçal, Prof. Dr. İlhan

[16] CAMPBELL, Neil A., REECE, Jane B.. Biology. Seventh Edition

In order to use a glass lantern, I choose to use a place like a conservatory where I find our balcony is proper, because the balcony has windows to prevent air exchange[17]. Also balcony being exposed to the sun and it could form a Greenhouse effect and could help building a drought ambience. There should be no loss of gas from the system. Amount of water is also very important for having accurate data. If the amount of water was more than needed, the plants could decay[18]. The amount of water for different experimental groups should be arranged well, because the droughtiness shows changes due to the aggregate of water. For deciding the optimal amount of water, a pre-experiment should be taken. This pre-experiment questions the optimal amount of water that will be used by the plants *Portuluca oleracea* and *Spinacia olecacea* during the experiment and could develop the method of the experiment. Using different amounts of water during the pre-experiment can answer the question 'What is the optimal amount of water that *Portuluca oleracea* and *Spinacia olecacea* use and show remarkable changes which is easy to observe?' For this, some trials made to be sure about the water amount and got the results of this experiment by measuring the root length.

A problem showed itself after deciding the amount of water used for the experiment. This problem was the amount of water increases as the amount of growing of the plant increases too. This augmentation occurs because of the needs that a growing plant has like producing more food for its growing root and leaf. In shorter plants needs more water to do more photosynthesis.

Amount of the water need by plants will increase day by day. But it cannot be taken under control so I decided to consider this variable as constant hence the amount of water which is needed by plants will be same.

[17] Karaçal, Prof. Dr. İlhan

[18] Karaçal, Prof. Dr. İlhan

Then it became important to make sure that all variables were under control. Light intensity, temperature, ph of water, salinity of water, amount and kind of soil, size of the flowerpots, distance of the flowerpots away from the windows of the balcony and avoiding the loss of gas. pH and salinity of water are very important to observe the changes and effects of different amount of water only. In addition, distilled water should not be used, because it had to contain every mineral which needed by a regular plant to do photosynthesis. For this I decided that drinking water can perfectly fit. I choose to use drinking water because salinity and pH of water is the same all the time and mentioned on the label of the bottle of water[19]. Also there is a risk that the water will be evaporating during the experiment. But I consider that the evaporating rate will be the same for all the flowerpots. Because evaporating rate is related with the surface area of the soil and I will use the flowerpots which have the same sizes. To make plants to do photosynthesis like they were in their habitat, flowerpots should be placed in equal distances from light to gain equal amounts of sun light. For this, I will place the flowerpots in a row and change their places daily. Also temperature should be at the average of 20-25 °C[20] and I decided to do my experiment in autumn. To measure the temperature of balcony I will place a thermometer. And in the flowerpots there will be a mixture of soil and sand for growing better.[21]

The method which decided to apply is weighing the masses of the flowerpots daily during the experiment including soil and the plants. I chose this procedure because daily weighing flowerpots can show the differences between the amounts of the used water by plants[22].

As Prof. Dr. İlhan Karaçal suggested me to use a soil-sand mixture which is used to plant the seeds in. Soil-sand mixture means that one flowerpots' mass contains 50% sand + 50% soil. This mixture can build an optimal media for plants to grow in. It helps the roots of the plants to grow healthy.[23] I will plant the seeds into the flowerpots after preparing soil-sand mixture.

[19] Karaçal, Prof. Dr. İlhan

[20] GRAHAM, E. Linda
GRAHAM, James M.
WILCOX , Lee W. Plant Biology

[21] Karaçal, Prof. Dr. İlhan

[22] Karaçal, Prof. Dr. İlhan

[23] Karaçal, Prof. Dr. İlhan

The experiment will take place 15 days after all plants have same length. Also I will cut extra leaves until all plants have same number of leaf. I cut extra leaves to keep constant the amount of photosynthesis for every plant. As the number of leaf increases, the amount of photosynthesis increases too.

I decided to apply my method in two parts. Part one (Method 1)will be the germination period of seeds and the second part (Method 2)will include the period after the plants grow and ready to show remarkable changes due to the amount of water. With this method, I expect to have data that I will need to reach a proper conclusion. Also with the method I planned, I become able to say that my present hypothesis is acceptable or not.

Method

Materials

30 *Portuluca oleracea* seeds

30 *Spinacia olecacea* seeds

6 flowerpots (15 cm radius, 10 cm deepness) (having a capacity of 0.900 kilograms)

2.625 kilograms of sand

2.625 kilograms of soil (ANADOLU Torf)

Drinking water (SAKA SU)

Digital weight (±0.1) (TEFAL Oasis 4, Ref: BC4002H0/26A-5007 R)

One Pencil

A balcony surrounded with windows

Thermometer (°C) (±0.01)

One pipette

Method 1:

2.625 kilograms of (Anadolu) (See appendix 2) soil was mixed with 2.625 kilograms of sand. The mixture was divided into 6, so every piece had 0.875 kilograms of soil-sand mixture. The pieces of 0.875 kilograms of soil-sand mixture were put in 6 flowerpots. By labeling flowerpots with giving them numbers from 1 to 6 made it easy to divide the flowerpots into two groups. The first group would have seeds of *Portuluca oleracea* and the second group would have *Spinacia olecacea* seeds. After dividing flowerpots into 6, there should be holes on the soil-sand mixture in every flowerpot for putting the seeds. For this with help of a pipette 10 holes were made on the surface of the soil-sand mixture. The deepness of each hole should be 2-3 cm and the distance between seeds had to be 3 cm.[24] (See diagram 1) By repeating this process for 5 more times for every flowerpot; every flowerpot had 10 holes each. The 10 of the *Portuluca oleracea* seeds were put in the holes of the first flowerpot. Each hole should have only one seed. Second and the third flowerpots had 10 seeds too. These steps were repeated for seeds of *Spinacia olecacea.* After putting all the seeds into the holes, preparing a proper place in balcony where was having sunlight very well were become

[24] Karaçal, Prof. Dr. İlhan

important. (See diagram 2) Changing the places of every flowerpot daily would equalize the angle and the amount of the exposed sun light to flowerpots. Watering all plants with SAKA SU (See Appendix 3) was best to keep the variables of water under control. The seeds were watering with the same amount of water, 0.1 kilogram. This watering process was continuing until seeds became one week old after they had sprouted. Putting a thermometer would help to observe the daily temperature changes. (See Appendix 4)

Method 2:

After all the seeds had sprouted and had the same length, starting to decide on a number of leaves became important to keep the photosynthesis amount constant. For this experiment having 10 leaves at every plant were decided. While this was happening two groups of seeds were divided into 3 groups again for having trials. So group one, *Portuluca oleracea* had 3 subgroups and at the same time Spinacia *olecacea* had 3 subgroups. After dividing the groups into 3, by weighing each of them add 0.2 kilogram of water which was decided from the results of the pre-experiment. After adding the 0.2 kilogram of water to each of the flowerpot were made them to become 1.075 kilograms. The windows and the door of the balcony should not be opened during the whole experiment in order not to ruin the drought ambience. Entering in balcony could be once daily for weighing flowerpots. Watering the flowerpots was very important to have data about daily change in the amount of water used in one day period. After having the same length and same number of leaves of the plants, another process would start. This process was to find out the daily amount of consummated water and add more water to equalize the masses of the plants to 1.075 kilograms. The aim of equalizing to 1.075 kilograms with adding water every day is to create the same conditions especially the water amount for plants to do photosynthesis. Each day all the flowerpots should be weighted to have a continuous data. Having these data for 15 days helped to reach a conclusion by using T-Test and state the acceptance of the present hypothesis.

Diagram 1: Diagram illustrating the setup of the experiment about the distances between seeds.

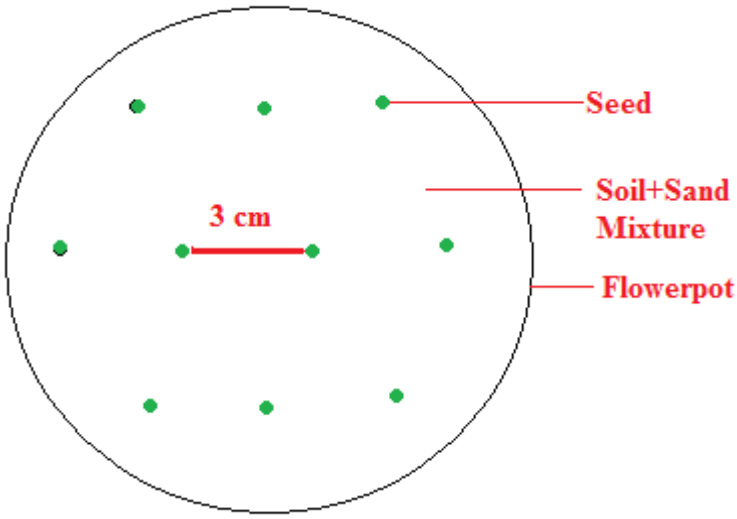
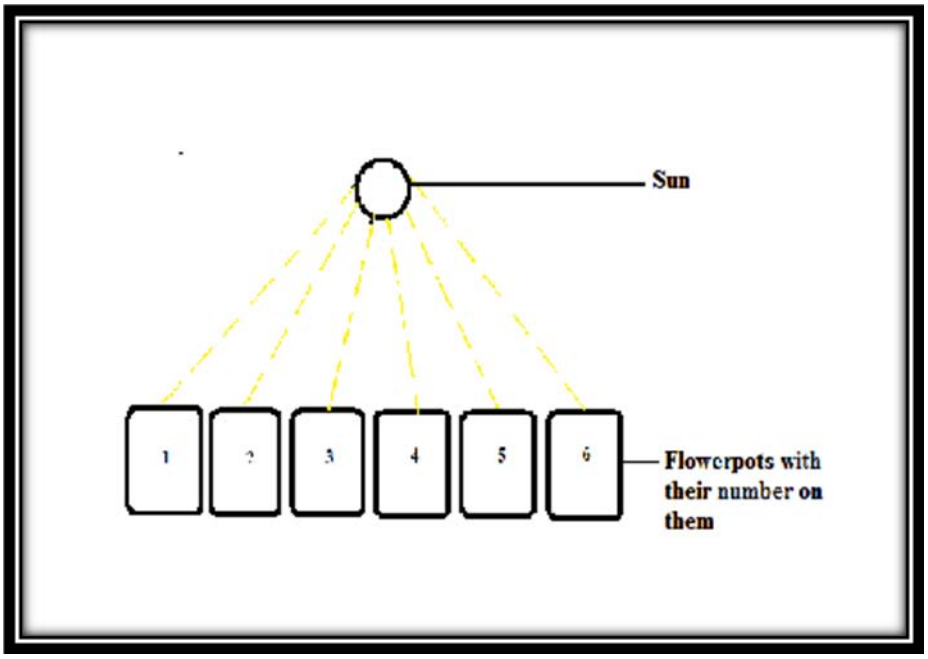


Diagram 2: Diagram illustrating the setup of the experiment about the distances of the flowerpots from the sun in the balcony.



Results

Trial Numbers	*Portuluca oleracea* trial 1	*Portuluca oleracea* trial 2	*Portuluca oleracea* trial 3	*Spinacia olecacea* trial 1	*Spinacia olecacea* trial 2	*Spinacia olecacea* trial 3
Weighs of the flowerpots	Weighs of the flowerpot1 (grams) (±0.1)	Weighs of the flowerpot2 (grams) (±0.1)	Weighs of the flowerpot3 (grams) (±0.1)	Weighs of the flowerpot4 (grams) (±0.1)	Weighs of the flowerpot5 (grams) (±0.1)	Weighs of the flowerpot6 (grams) (±0.1)
Day 0	875.0	875.0	875.0	875.0	875.0	875.0
Day 1	1075.0	1075.0	1075.0	1075.0	1075.0	1075.0
Day 2	1052.0	1060.0	1050.0	1020.0	1028.0	1031.0
Day 3	1045.0	1032.0	1038.0	1033.0	1032.0	1025.0
Day 4	1053.0	1050.0	1045.0	1037.0	1024.0	1031.0
Day 5	1037.0	1045.0	1051.0	1029.0	1018.0	1022.0
Day 6	1054.0	1052.0	1055.0	1037.0	1040.0	1029.0
Day 7	1037.0	1029.0	1031.0	1019.0	1034.0	1028.0
Day 8	1049.0	1050.0	1043.0	1025.0	1029.0	1034.0
Day 9	1040.0	1055.0	1050.0	1012.0	1020.0	1009.0
Day 10	1047.0	1042.0	1051.0	998.0	1013.0	994.0
Day 11	1059.0	1050.0	1053.0	1009.0	992.0	1013.0
Day 12	1045.0	1045.0	1042.0	1025.0	1028.0	1031.0
Day 13	1055.0	1048.0	1056.0	1024.0	1033.0	1029.0
Day 14	1043.0	1050.0	1041.0	1029.0	1036.0	1040.0
Day 15	1056.0	1048.0	1050.0	1021.0	1030.0	1019.0

Table 1: Table shows the daily data of weighs of the flowerpots of the experiment.

	Weigh differences of the flowerpot1 (*Portuluca oleracea)* from 1075.0 grams of soil-sand mixture (±0.1)	Weigh differences of the flowerpot2 (*Portuluca oleracea)*from 1075.0 grams of soil-sand mixture (±0.1)	Weigh differences of the flowerpot3 (*Portuluca oleracea)*from 1075.0 grams of soil-sand mixture (±0.1)
Day 1	0.0	0.0	0.0
Day 2	23.0	15.0	25.0
Day 3	30.0	43.0	37.0
Day 4	22.0	25.0	30.0
Day 5	38.0	30.0	24.0
Day 6	21.0	23.0	20.0
Day 7	38.0	46.0	44.0
Day 8	26.0	25.0	32.0
Day 9	35.0	20.0	25.0
Day 10	28.0	33.0	24.0
Day 11	16.0	25.0	22.0
Day 12	30.0	30.0	33.0
Day 13	20.0	27.0	19.0
Day 14	32.0	25.0	34.0
Day 15	19.0	27.0	25.0

Table 2: Table shows the daily water need of *Portuluca oleracea*

	Weigh differences of the flowerpot4 (*Spinacia olecacea)* from 1075.0 grams of soil-sand mixture (±0.1)	Weigh differences of the flowerpot5 (*Spinacia olecacea)* from 1075.0 grams of soil-sand mixture (±0.1)	Weigh differences of the flowerpot6 (*Spinacia olecacea)* from 1075.0 grams of soil-sand mixture (±0.1)
Day 1	0.0	0.0	0.0
Day 2	55.0	47.0	44.0
Day 3	42.0	43.0	50.0
Day 4	38.0	51.0	44.0
Day 5	46.0	57.0	53.0
Day 6	38.0	35.0	46.0
Day 7	56.0	41.0	47.0
Day 8	50.0	46.0	41.0
Day 9	63.0	55.0	66.0
Day 10	77.0	62.0	81.0
Day 11	66.0	83.0	62.0
Day 12	50.0	47.0	44.0
Day 13	51.0	42.0	46.0
Day 14	46.0	39.0	35.0
Day 15	54.0	45.0	56.0

Table 3: Table shows the daily water need of *Spinacia olecacea*

Data Analysis

The mean values calculated of the data seen in the tables 2 and 3 to use them in T-Test.

	Mean values of Weigh differences of the *Portuluca oleracea* from 1075.0 grams of soil-sand mixture (±0.1)	Mean values of Weigh differences of the *Spinacia olecacea* from 1075.0 grams of soil-sand mixture (±0.1)
Day 1	00.0	00.0
Day 2	25.0	48.6
Day 3	36.6	45.0
Day 4	25.6	44.3
Day 5	30.6	52.0
Day 6	21.3	39.6
Day 7	42.6	48.0
Day 8	27.6	45.6
Day 9	26.6	61.3
Day 10	28.3	73.3
Day 11	21.0	70.3
Day 12	31.0	47.0
Day 13	22.0	46.3
Day 14	30.3	40.0
Day 15	23.6	51.6

Table 4: Table shows the daily water need of the *Portuluca oleracea* and *Spinacia olecacea*

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.

The results of the T-Test:

	Group 1	**Group 2**
Mean	26.140	47.527
Standard deviation	9.283	16.499
Standard Error of mean	2.397	4.260
Number of Data	15	15

Table 5: Table shows the results of the T-Test.

t = 4.3753

df = 15+15=30

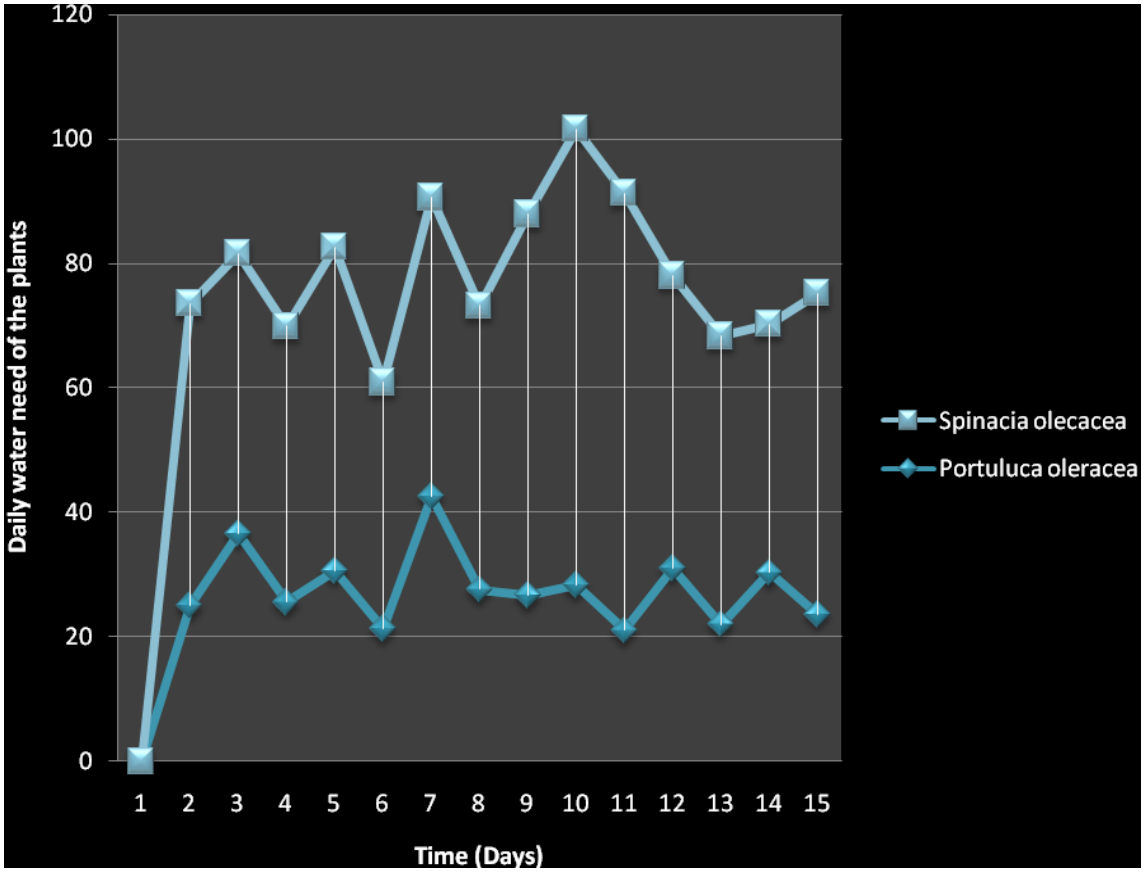
30-2= 28

Standard error of difference = 4.888

The two-tailed p value equals 0.0002

A T table is needed to compare the results of the T-Test and to reach a conclusion. Using degrees of freedom (df) and with help of the T table, I finally reached a conclusion that there is an obvious difference between two sets of data. (See Appendix 5) By the result of the

T-Test the t value is bigger than 3.6739. (4.3753>3.6739) 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: Graph shows the daily water need (taken from Results Table 4) of *Spinacia olecacea* and *Portuluca oleracea*.

Conclusion and Evaluation

The results support the hypothesis; there is a difference between *Portuluca oleracea* and *Spinacia olecacea* in using water in the case of droughtiness. (See Data Analysis) After 15 days of equalizing the masses of the *Portuluca oleracea* and *Spinacia olecacea* with watering to 1.075 kilograms, the results show that *Portuluca oleracea* uses less water than *Spinacia olecacea* in the same conditions like being in droughty place. This difference in the usage of water comes from being a C_3 and C_4 plants.[24] As it can be seen from results of the experiment *Spinacia olecacea* needs more water during doing photosynthesis because of being a C_3 plant. (See Results) On the other hand *Portuluca oleracea* uses less water and does photosynthesis sufficiently. This specialty comes from being a C_4 plant. By preparing an environment which was a droughty place for the plants I could observe the adaptations they had for the lack of water. Water amounts used by *Portuluca oleracea* was different from the used water of *Spinacia olecacea* even they both had the same properties like having same germination period.[25] As it can be understood from the results of the experiment *Portuluca oleracea* can minimize the unexpected consequences of the greenhouse effect which can eradicate plants whereas *Spinacia olecacea* cannot deal with these consequences well enough like *Portuluca oleracea* does.

The growing differences can be clearly seen from the color and the size of the leaves of both plants. *Portuluca oleracea's* leaves were greener and healthier than the leaves of *Spinacia olecacea*. (See Appendix 6) Also the amount of daily used water differences showed the dissimilarities of each plant. I stated that I decided to ignore the vaporization of water from the flowerpots during the experiment. This ignorance did not change the results because all flowerpots had the same diameter and vaporization occurred from the surface area of the pots. So vaporization was same for all flowerpots. As the days went by the temperature increased in the closed balcony and this heating up built an ambience of greenhouse effect. Increasing the number of days that the experiment would take place could make the results more accurate and healthier. I tried to make my experiment as accurate as it could be but there were still some little details that I could not take under control. While I was entering in the balcony for weighing the flowerpots, I had to open the door and some air could exchange which could form an error source. To overcome this error source, a nonconductive matter could be used to avoid the gas and heat exchange. All the flowerpots placed equally at the sunlight, so the angle of the light could not be an error source. Also I tried to water the plants at the same hour

every day. Cleaning plants leaves gently could prevent any bacterial sickness. I emptied the balcony and left only the *Spinacia olecacea* and *Portuluca oleracea* to contrast them, also emptying the balcony and leaving no other plant to prevent my experiment to be affected from other plants. To improve this experiment, more trials can be done. Also the experiment can take place in a conservatory.

At the end of the experiment, it is proven that being a C_3 or C_4 plant affects the usage of water during the consequences of greenhouse effect. By using the method T-Test I compared the two sets of different data to see if they can be considered to be the same or not. By the result of the T-Test the t value is bigger than 1.701131(See Data Analysis and appendix 7) So I rejected my null hypothesis. By rejecting the null hypothesis I accepted that there are significant differences between the two sets of data.

As it can be seen from the graphs, mean values of the weigh differences of *Spinacia olecacea* and *Portuluca oleracea* are significantly different from each other. From the second graph the mean differences can be observed and there are significant weigh differences between *Spinacia olecacea* and *Portuluca oleracea* because of their capacity of using water thrifty. *Spinacia olecacea* uses more water to do photosynthesis whereas *Portuluca oleracea* uses less water. It can be proved from the data of the mean values of the 15 days weigh differences, *Spinacia olecacea* weigh difference is 47.5and *Portuluca oleracea* is 26.1.

As yet no-one can be able to suggest solutions of a universal problem, droughtiness. There should be lots of researches about this dangerous problem without harming animals and people. People will not have enough places to plant plants in future. In order to have more places a technique had developed. This technique is called ‘Green roofs’ (See Appendix 8) Planting *Portuluca oleracea* in Green Roofs can be a solution for place problem. But further research should be done on the effects of green roofs to reduce the consequences of Global Warming.

It is proven that there are significant differences between *Portuluca oleracea* and *Spinacia olecacea* on the usage of water. However, a question can be asked about if planting the *Portuluca oleracea* in the places where doughtiness occurring will be enough to provide food for everyone. It may be an effective way to gain food but this cannot be a long-term solution for doughtiness. This limited food source cannot be enough for both animals and people. Planting *Portuluca oleracea* everywhere does not have a financial damage. Also this does not give damage to the environment

Appendices

Appendix 1:

I firstly put the seeds of *Portuluca oleracea* and *Spinacia olecacea* in different flowerpots and left them in a balcony which is not isolated from outside and not seclude from sun for 10 days by giving 0.1 liters of drinking water daily. I started the experiment after all the seeds germinated and first sprouted. The seeds germinate in nearly 8 or 10 days. I used seed in order to use sapling to take every variable under control. I separated the *Portuluca oleracea* and *Spinacia olecacea* into three groups. The first one has the least amount of water; 0.1 liters, second group has 0.2 liters of water and the third one has 0.4 liters of water.

After 10 days the pre-experiment had started, I measured the lengths of roots of *Portuluca oleracea* and *Spinacia olecacea* so this showed the amount of growth related with the optimal amount of water used during photosynthesis. With the help of a spoon I separated the plants from soil and measured the lengths of each root with a ruler. The results showed that 0.2 liters of water fits best to the present hypothesis, so the method of the experiment planned better.

	Portuluca oleracea which has 0.1 liters of water			*Portuluca oleracea* which has 0.2 liters of water			*Portuca olerace a* which has 0.4 liters of water			*Spinacia olecacea* which has 0.1 liters of water			*Spinacia olecacea* which has 0.2 liters of water			*Spinacia olecace a* which has 0.4 liters of water		
Root lenght (cm) (±0.01)	5.0	5.4	5.8	7.2	7.8	6.5	6.1	6.3	6.0	5.6	6.8	5.9	7.4	6.7	6.2	6.5	6.2	5.7
Mean of root lenght (cm) (±0.01)	5.4			7.2			6.2			6.1			6.7			6.1		

Appendix Table 1: Table shows the root length and mean of root length of the pre-experiment at the end of the 10 days.

Appendix 2:

Soil: Anadolu Torf (anatoh@anatoh.com)

pH: 6-7

EC: 1-2 mS/cm

Purity: min. 95%

Appendix 3:

Ingredients of 'SAKA SU' (http://www.saka.com.tr/index.asp?w=10092&l=1)

Calcium (mg/lt Ca)	:	32,2
Magnesium (mg/lt Mg)	:	4,2
Sodium (mg/lt Na)	:	5,4
Potassium (mg/lt K)	:	0,2
pH	:	8,1
Chloride (mg/lt Cl)	:	1,2
Nitrate (mg/lt NO3)	:	1,6
Nitrite (mg/lt NO2)	:	Non
Sulphate (mg/lt SO4)	:	6,9
Bicarbonate (mg/lt HCO3)	:	104,92
Net Mineralization (mg/lt)	:	176,89

Appendix 4:

Number of Days	Temperature (°C) (±0.01)
1	23.00
2	25.00
3	25.00
4	26.00
5	27.00
6	28.00
7	28.00
8	26.00
9	28.00
10	25.00
11	25.00
12	26.00
13	26.00
14	28.00
15	28.00

Appendix Table 1: Table shows the daily temperatures of the balcony.

Appendix 5:

Table showing the values of degrees of freedom and p values.

df\p	0.40	0.25	0.10	0.05	0.025	0.01	0.005	0.0005
1	0.324920	1.000000	3.077684	6.313752	12.70620	31.82052	63.65674	636.6192
2	0.288675	0.816497	1.885618	2.919986	4.30265	6.96456	9.92484	31.5991
3	0.276671	0.764892	1.637744	2.353363	3.18245	4.54070	5.84091	12.9240
4	0.270722	0.740697	1.533206	2.131847	2.77645	3.74695	4.60409	8.6103
5	0.267181	0.726687	1.475884	2.015048	2.57058	3.36493	4.03214	6.8688
6	0.264835	0.717558	1.439756	1.943180	2.44691	3.14267	3.70743	5.9588
7	0.263167	0.711142	1.414924	1.894579	2.36462	2.99795	3.49948	5.4079
8	0.261921	0.706387	1.396815	1.859548	2.30600	2.89646	3.35539	5.0413
9	0.260955	0.702722	1.383029	1.833113	2.26216	2.82144	3.24984	4.7809
10	0.260185	0.699812	1.372184	1.812461	2.22814	2.76377	3.16927	4.5869
11	0.259556	0.697445	1.363430	1.795885	2.20099	2.71808	3.10581	4.4370
12	0.259033	0.695483	1.356217	1.782288	2.17881	2.68100	3.05454	4.3178
13	0.258591	0.693829	1.350171	1.770933	2.16037	2.65031	3.01228	4.2208
14	0.258213	0.692417	1.345030	1.761310	2.14479	2.62449	2.97684	4.1405
15	0.257885	0.691197	1.340606	1.753050	2.13145	2.60248	2.94671	4.0728
16	0.257599	0.690132	1.336757	1.745884	2.11991	2.58349	2.92078	4.0150

17	0.257347	0.689195	1.333379	1.739607	2.10982	2.56693	2.89823	3.9651
18	0.257123	0.688364	1.330391	1.734064	2.10092	2.55238	2.87844	3.9216
19	0.256923	0.687621	1.327728	1.729133	2.09302	2.53948	2.86093	3.8834
20	0.256743	0.686954	1.325341	1.724718	2.08596	2.52798	2.84534	3.8495
21	0.256580	0.686352	1.323188	1.720743	2.07961	2.51765	2.83136	3.8193
22	0.256432	0.685805	1.321237	1.717144	2.07387	2.50832	2.81876	3.7921
23	0.256297	0.685306	1.319460	1.713872	2.06866	2.49987	2.80734	3.7676
24	0.256173	0.684850	1.317836	1.710882	2.06390	2.49216	2.79694	3.7454
25	0.256060	0.684430	1.316345	1.708141	2.05954	2.48511	2.78744	3.7251
26	0.255955	0.684043	1.314972	1.705618	2.05553	2.47863	2.77871	3.7066
27	0.255858	0.683685	1.313703	1.703288	2.05183	2.47266	2.77068	3.6896
28	0.255768	0.683353	1.312527	1.701131	2.04841	2.46714	2.76326	3.6739
29	0.255684	0.683044	1.311434	1.699127	2.04523	2.46202	2.75639	3.6594
30	0.255605	0.682756	1.310415	1.697261	2.04227	2.45726	2.75000	3.6460

(http://www.statsoft.com/textbook/sttable.html)

Appendix 6:

Picture 1: The photo shows the *Portuluca oleracea* in the flowerpot at day 15.

Picture 2: The photo shows the *Spinacia olecacea* in the flowerpot at day 15.

Appendix 7:

Calculating the means of weigh differences helped me to compare those data whether they are same of totally different. But test should be done to prove this difference statically. So I decided to use T-Test. Student's T-Test is a test when comparing two sample means.*

$$t = \frac{\overline{X_1} \quad \overline{X_2}}{\sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}}$$

X: Mean

SD: Standart deviation

n: Number of data

After finding that there is a significant difference between two sets of data, I have to form null hypothesis. Null hypothesis (H_0) states that there is no significant difference between two sets of data. At the other hand, H_1 states the opposite.

(http://www.idrc.ca/en/ev-56463-201-1-DO_TOPIC.html)

(* http://www.graphpad.com/quickcalcs/ttest2.cfm

Appendix 8:

Green roofs are like gardens which are used to reduce extreme heating because of the Greenhouse effect. Green roofs filter the pollutants, heavy metals in the rain water and CO_2 in the air. Researches stated that green roofs can decrease the temperature by reducing the Greenhouse gas emission without harming living organisms. Related with my hypothesis, *Portuluca oleracea* can be planted on those roofs. Planting this plant on the roofs can be a solution for both the place problem in the big cities and for droughtiness but there are plenty of research about this technique. Further research should be done to test the validity of the Green roofs.

A roof of a building in Manhattan

A roof of a building in Chicago

(http://www.greenroofs.com/, http://en.wikipedia.org/wiki/Green_roof, http://www.greenroofs.org/index.php?option=com_content&task=view&id=26&Itemid=40#water)

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