IB Extended Essay Biology

Research on the effects of sulfuric acid (H_2SO_4) on the growth rate of *Hellianthus annuus* (Sunflower)measured in terms of height

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Abstract

This experiment focused on the effects of sulfuric acid to the agricultural plant, sunflower (*Hellianthus annuus*) and the research question is "How is the growth of *Helianthus annuus* (Sunflower) in terms of height (cm) effected by different concentrations of sulfuric acid (H_2SO_4) solutions added to different groups while the soil quality, temperature and pressure is tried to be constant for all groups?"

This research is focused on the effects of different concentrations of acidic solution on *Helianthus annuus* (Sunflower) plant. Acidic solutions was obtained from mixing sulfuric acid (H_2SO_4) with water. 0, 25, 50, 75 and 100 mililiters of acid is present in 1 liter (1000 mL) solutions respectively. The samples were observed for 20 days and their growths were measured.
There was a clear difference in growth between the groups. Experimental results supported my hypothesis that is **''Different concentrations of sulfur dioxide solutions will affect the growth rate of *Hellianthus annuus* (Sunflower).''**

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INTRODUCTION

The first time I needed to choose a topic that is going to be investigated I thought that biology has a great importance in our lives and spread over in large areas so at first I was unable to decide my investigation topic, but one day, I read that a 1984 Congressional report showed that in the United States and Canada, acid rain caused the premature death of about 50,000 people.[1] [1] I also learned that researchers now know that acid rains cause injury, death, and slower growth of forests. Acid rain has been implicated in soil degredation particularly in the eastern United States, such as Shenandoah and Great Smoky Mountain National Park, Maine Appalachian Mountains in Georgia, especially in high-elevation forests.[2] After learning about the harmfull effects of acid rain I thought it would be a good topic for me to do a research on and I decided to work on the effects of the acid rain to plants.

In today's world environmental pollution is one of the biggest problems and one of the harmful returns to the world is acid rains.[3] Rain that has been made acidic by carbon dioxide, sulfur dioxide and nitrogen oxides which react with the water molecules in the atmosphere to produce acids is called acid rain. [4]

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[1] *Chemistry of the Environment (Second Edition)*, *2002*, *Pages 223-293*
[2] *Forest Ecology and Management*, *Volume 63, Issues 2–3*, *February 1994*, *Pages 247-300*
[3] *Advances in Agronomy*, *Volume 84*, *2004*, *Pages 37-120*
[4] *Atmospheric Environment. Part A. General Topics*, *Volume 25, Issue 1*, *1991,Pages 190-203*

Sulfur trioxide is the most important gas which leads to acidification.[5]Sulfur trioxide (SO_3) comes from fossil fuel combustion, wildfires and from volcanoes.[6]These substances combine with water vaporin the airto form sulfuric acid.

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

(Sulfur trioxide + Water $\longrightarrow$ *Sulfuric acid)*

I researched on the affects of acidity on plants and found that both natural vegetation and crops are affected by acid rain. The roots are damaged by acidic rainfall, causing the growth of the plant to be stunted, or even in its death. Nutrients present in the soil, are destroyed by the acidity. Useful micro organisms which release nutrients from decaying organic matter, into the soil are killed off, resulting in less nutrients being available for the plants.[7] The acid rain, falling on the plants damages the waxy layer on the leaves and makes the plant vulnerable to diseases.[8]The cumulative effect means that even if the plant survives it will be very weak and unable to survive climatic conditions like strong winds, heavy rainfall, or a short dry period.

[5]*Environmental Pollution*, *Volume 110, Issue 1*, *October 2000*, *Pages 89-102*
[6]*Clinical Veterinary Toxicology, 2004, Pages 337-338,cp1-cp8,339-442*
[7] *Advances in Agronomy, Volume 101, 2009, Pages 283-313*

[8]*Industrial Crops and Products, Volume 31, Issue 3, May 2010, Pages 481-491*

Germination and reproduction of the plant is also inhibited by the effects of acid rain.[9]

Since I am asking the question, "What will happen if agricultural plants are exposed to acid rain?"I decided to work on the specie *Helianthus annuus* (Sunflower) because in Turkey's Marmara region sunflowers are cultivated and there are many factories there.

Sunflowers grow best in fertile, moist, well-drained soil with heavy mulch. need full sun to grow best. They need full sun to grow best. To provide the best development seeds are planted 45 cm (1.5 ft) apart and 2.5 cm (1 in) deep.[10]

Sunflower seeds are used today as bird food, a nutritious snack, for sprouting, cooking oil, medicine, and animal feed. Sunflower oil is used for biodiesel fuel and the sunflower plant is used to clean toxins from the environment.

According to modern taxonomy Sunflower is from the Plantae kingdom, Angiospermae division, Eudicots subdivision, Asterids class, Asterales

[9]*Field Crops Research, Volume 30, Issues 3–4, September–October 1992, Pages 195-230*
[10]*Field Crops Research, Volume 39, Issue 1, October 1994, Pages 49-57*

order, Asteraceae family, Helianthoideae subfamily, Heliantheae tribe and Helianthus genus.

Before the actual experiment a couple of *Helianthus annuus* (Sunflower) seeds were planted to see check if it was appropriate for my experiment and how it would grow. The seeds germinate within a few days. Also *Helianthus annuus* (Sunflower) has a straight stem that makes length measurements easier. So *Helianthus annuus* (Sunflower) is a very appropriate specie for this experiment.

This research is narrowed down on the effects of different concentrations of acidic solution on *Helianthus annuus* (Sunflower) plant. Acidic solutions was obtained from mixing sulfuric acid (H_2SO_4) with water.

This experiment will focus on the research question:

"How is the growth of *Helianthus annuus* (Sunflower) in terms of height (cm) effected by different concentrations of sulfuric acid (H_2SO_4)solutions added to different groups while the soil quality, temperature and pressure is tried to be constant for all groups?"

Hypothesis

The sulfur dioxide and emissions causes in SO_3 production in air so the pH of the rain water to drop below 5.5, the acidity of the rain water cannot be neutralised by the soil so at this level it is considered to be an acid rain. It can be predicted that of the plant would be inhibited and acidity would be observed by examining the proportions which was used in the experiment. If any toxic effect is observed, it would show that plant growth is affected by changing acid quantities. Consequently it can be hypothesized that,

H_1: Different concentrations of sulfuric acid solutions will affect the growth rate of *Helianthus annuus* (Sunflower).

H_0: Different concentrations of sulfuric acid solutions will not affect the growth rate of *Helianthus annuus* (Sunflower).

METHOD DEVELOPMENT AND PLANNING

To perform this experiment a convenient method should be developed.There are too many variables that may change the result so all the variables, except for the independent variable which is the amount of sulfuric acid put in the soil in this particular experiment, must be kept constant. In this investigaton the dependent variable is the growth of *Helianthus annuus* (Sunflower) measured by height of the plant (in cm). Other variables that should be tried to kept constant otherwise they could affect the results are given below.

•Acid source

•Acid adding time

•Soil quantity

•Soil source (composition)

•Watering quantity

•Water source

•Watering time

•Watering technique

•Height of soil under and on the seed

•Suppression of soil

•Cup size, width, height

•Similar seed weight, color, size, appearance (genetic variation)

•Seed planting height (vertical)

•Seed planting place (horizontal)

•Room temperature

•Room pressure

•Humidity level

•Surrounding air

•Light exposure

• Light intensity

•Time interval and measurement time

Apparatus / Materials Needed For This Experiment

•*Helianthus annuus* (Sunflower) seeds (x25)

•5 liter Javsu natural spring water

•Soil(10 liters or 4.9 kg)

• Sulfuric acid

•Pot (Diameter:10.00cm.Height:10.00cm) (See diagram 1)

•pH meter

•50 cm ruler (± 0.05 cm)

•500 mL beaker (± 5 mL)

•20 mL injector (± 0.05 mL)

•Digital weight (± 0.001 g)

•Rope (at least 50 cm long)

•Jars or any airtight container (x4)

•Pen

•50 mL Graduated cylinder (± 0.05 mL)

•Labeling stickers (x25)

One of the most essential substances for plant growth is water.It performs the following important functions in plants:

1. Water is necessary for the germination of seeds and growth of plants.

2. Plants synthesize nutrient from carbon dioxide and water during the process of photosynthesis,

3. Water acts as a resolvent for minerals and fertilizers, which are taken up by the plant roots in solution form. Thus, water helps the plants to absorb soluble nutrients from the soil.

4. Water is essential for transportation of chemicals to and from cells.

5. In plant cells water pressure provides the firmness to the plants.

Because water is so essential, it has to be given carefully. The most common cause of death in plants is over-watering. If the roots of a plant are surrounded by water, they cannot absorb oxygen. Thus for each cup once two days 10 mL water should be given. Selected watering time is 20:00 because during day time water may evaporate and become less effective.It's important to give water homogenously.

Chemical properties of water is also important so the same water – Javsu Natural Spring Water from Kızılcahamam – will be used for each cup. Parametric values of water is given at Table 1.

Parameter	Parametric Value	Results	Unit
Aluminum	200	5	Pg/l
Ammonia	0,5	0,05	Mg/l
Chlorine	250	1,2	Mg/l
Colour	Acceptable	Appropriate	-
Conductivity	2.500	185	pS/cm
pH	$\geq 6,5 \leq 9,5$	7,58	pH
Iron	200	11	Pg/l
Manganese	50	2	Pg/l
Odor	Acceptable	Appropriate	-
Oxidizability	5	0,6	Mg/l
Sulfate	250	1,4	Mg/l
Sodium	200	9	Mg/l
Taste	Acceptable	Appropriate	-

Table 1: Parametric properties of the water used in the experiment.

As shown in the Table 1Parametric values of the water that will be used – Javsu Natural Spring Water from Kızılcahamam – is appropriate for this investigation.

This experiment will focus on the effects of acid rain to plant growth so sulfuric acid (H_2SO_4) should be given after the germination of the seeds.Thus, each test tube start its normal germination at first.

Additionally, soil type is very important for plant growth. Plant's roots suck up the nurients into the plant to provide food from the soil.

To provide the plants equal area of growth equal cups must be used for each.

10 liters of soil (weighing 4.9kg) is going to be used. Divide the soil 25 by volume, so each test subject includes 400 mL soil weighing 108 grams. Split the soil into two layers and put the seed between these layers. First layer must be 7.50 cm high. The seed is placed on the top of the soil then 2.50 cm of additional soil is put (See diagram 2). The quantities of the soil should be same for every plant. To avoid closing the air gaps and to demonstrate the natural conditions, soil must not be pressed, pressing would close the air gaps in the soil. With less air present, respiration rate of roots could be affected therefore resulting with less growth.

If the roots of plant touch to the surface of the cup, an unwanted situation can occur. Therefore, seeds must be put at the horizontal center and vertically 7.50 cm height (See diagram 2) and to reduce the contact the seeds must be at the center of the cup where the distance between the surface and seed is maximum.

All room conditions(humidity, temperature) must kept constant for plants so all the test subjects must kept at the same room. For all plants the experiment started at the same time. The rate of growth will also be effected by the factors which effects the rate of photosynthesis. One of these factors is light intesity. To have a constant light intensity, cups must be placed in the same

area therefore there will be no light receiving differences or shadows shading some plants.

The investigation starts on 15th February (Day 1) and ends in 20 days,on 6th March (Day 20). At the same time Daily measurements were taken.

Diagrams

Diagram 1: *Diagram showing the plastic cups used in the experiment*

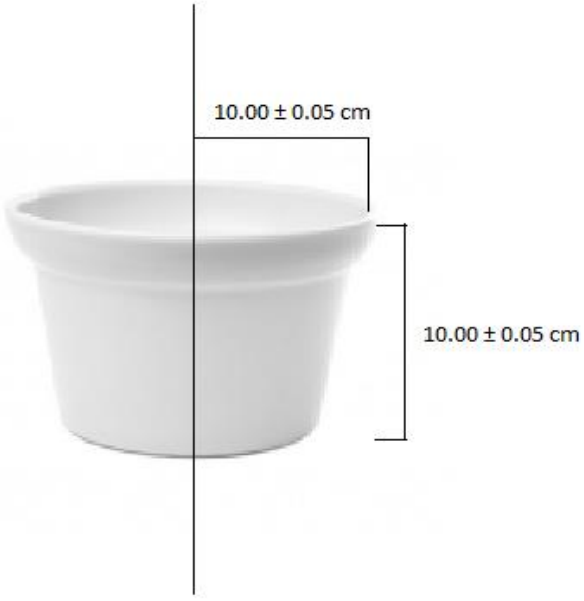


Diagram 2: *Diagram showing the placing of the seed.*

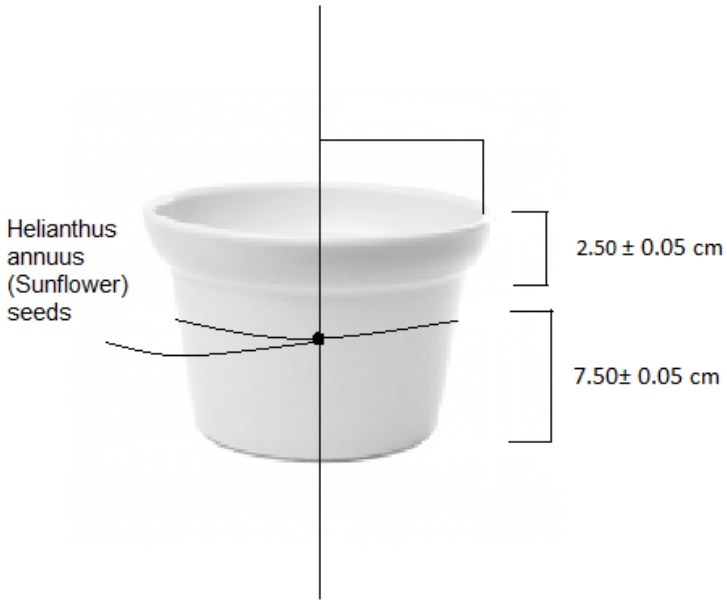


Diagram 3: *General setup of the experiment groups.*

Group 1 Group 2 Group 3

0.00 ml H_2SO_4 / 1 liter water for each plant

25.00 ml H_2SO_4 / 1 liter water for each plant

50.00 ml H_2SO_4 / 1 liter water for each plant

Group 4 Group 5

/

75.00 ml H_2SO_4 / 1 liter water for each plant

100.00 ml H_2SO_4 / 1 liter water for each plant

Method

1. 25 plastic pots were prepared and labelled.

	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
SAMPLE 1	G1S1	G2S1	G3S1	G4S1	G5S1
SAMPLE 2	G1S2	G2S2	G3S2	G4S2	G5S2
SAMPLE 3	G1S3	G2S3	G3S3	G4S3	G5S3
SAMPLE 4	G1S4	G2S4	G3S4	G4S4	G5S4
SAMPLE 5	G1S5	G2S5	G3S5	G4S5	G5S5

Table 2: Labeling system for five samples for each of the five groups. “G” shows the group number and “S” shows the sample number.

2.Concentrations for the acid solutions are given below. By using a volumetric flask measure 0, 25, 50, 75 and 100 mililiters ofsulphuric acid (H_2SO_4). After that mix each of the them with 1 liter water separately. Use only Javsu Natural Spring Water.

3.Pour the solutions into airtight containers. Evaporation will increase the acid concentration and cause a source of error so solutions must be kept in closed containers to prevent evaporation.0, 25, 50, 75 and 100 mililiters of acid is present in 1 liter (1000 mL) solutions respectively. Every 10 milliliters taken from this solutions would have 0, 0.25, 0.50, 0.75 and 1.00 mililiters.

4. Same type of soil is poured into plastic cups. All the cups must be

equal. Soil which is 7.50 cm in height must be poured and then the *Hellianthus Annuus (Sunflower)* seed is added. A second layer of soil (about 2.50 cm) is put on the treat so the final height of the soil is 10 cm. (See diagrams 1 and 2)

5. Once for every two days the plants were watered with 10 mL varying acid solutions at 20:00. For keeping the water quantitiy constant 10 mL of water must alwyas be given with an injector regardless with the acid amount.

6.At the same time plant heights must be measured daily. To measure the height of the plant easily, a rope can be used. One end of the rope is extended to touch the end of the plant and the other end was held at the base of the plant, the rope and stem is closer as possible to each other because a gap may result in wrong measurements. By a help of a ruler the distance obtained with the rope can be measured: the two ends are held and the ruler is placed between them.

Results and Analysis

		GROUP 1 (NO ACID ADDITION)				
STEM LENGTHS OF SUNFLOWERS MEASURED FOR 20 DAYS (±0.1cm)		G1S1	G1S2	G1S3	G1S4	G1S5
	DAY 1	0.24	0.26	0.32	0.42	0.20
	DAY 2	0.95	1.02	0.83	0.91	0.88
	DAY 3	1.62	1.93	1.76	1.82	1.83
	DAY 4	2.12	2.39	2.81	2.94	2.14
	DAY 5	3.87	3.95	3.93	4.32	3.76
	DAY 6	4.34	5.06	5.87	5.95	4.97
	DAY 7	6.78	6.37	6.82	7.61	6.19
	DAY 8	7.82	7.08	8.01	8.77	7.04
	DAY 9	8.33	8.14	8.90	9.48	8.59
	DAY 10	9.64	9.98	9.56	10.59	9.23
	DAY 11	10.76	11.41	10.29	11.93	10.81
	DAY 12	11.97	13.49	11.99	13.76	11.26
	DAY 13	13.77	15.73	15.62	15.12	12.87
	DAY 14	14.38	16.67	16.31	16.91	14.67
	DAY 15	15.49	17.45	17.06	17.04	15.28
	DAY 16	16.70	18.96	18.99	18.25	16.33
	DAY 17	17.71	19.44	19.43	19.10	17.47
	DAY 18	18.02	21.48	20.89	21.17	18.66
	DAY 19	19.43	23.60	22.15	22.34	20.28
	DAY 20	21.04	25.00	24.46	24.19	21.39

Table 3: Results for group 1.(G: group, S: sample)

		GROUP 2 (25 mL ACID ADDED)				
STEM LENGTHS OF SUNFLOWERS MEASURED FOR 20 DAYS (±0.1cm)		G2S1	G2S2	G2S3	G2S4	G2S5
	DAY 1	0.33	0.28	0.40	0.19	0.35
	DAY 2	1.08	1.03	0.94	0.88	1.12
	DAY 3	1.92	2.05	1.58	1.16	2.23
	DAY 4	2.32	2.98	2.16	2.41	3.02
	DAY 5	3.17	3.35	3.44	3.38	3.97
	DAY 6	4.31	4.22	4.17	4.35	5.01
	DAY 7	5.73	5.37	5.02	5.61	6.29
	DAY 8	6.87	6.08	6.44	7.02	7.64
	DAY 9	7.13	7.04	7.31	8.14	8.57
	DAY 10	8.44	8.18	8.59	9.76	9.83
	DAY 11	9.57	9.41	9.75	10.50	10.85
	DAY 12	10.97	11.65	11.79	12.92	12.29
	DAY 13	12.35	13.53	14.02	14.88	14.74
	DAY 14	14.21	15.67	16.14	16.53	16.07
	DAY 15	15.37	16.65	17.00	17.12	17.08
	DAY 16	16.00	17.56	18.70	18.35	18.34
	DAY 17	17.44	18.63	19.56	19.16	19.46
	DAY 18	18.05	20.62	20.99	20.85	21.07
	DAY 19	19.26	22.55	22.06	22.24	22.21
	DAY 20	21.51	24.20	24.83	24.59	23.86

Table 4: Results for group 2.(G: group, S: sample)

		GROUP 3 (50 mL ACID ADDED)				
STEM LENGTHS OF SUNFLOWERS MEASURED FOR 20 DAYS (±0.1cm)		G3S1	G3S2	G3S3	G3S4	G3S5
	DAY 1	0.21	0.23	0.19	0.25	0.29
	DAY 2	0.64	0.52	0.57	0.41	0.58
	DAY 3	1.02	1.09	1.06	1.12	1.53
	DAY 4	1.63	1.76	1.71	1.94	2.14
	DAY 5	2.47	2.42	2.53	2.32	3.16
	DAY 6	3.67	3.06	3.26	3.15	3.97
	DAY 7	4.78	4.17	4.02	5.22	5.18
	DAY 8	5.83	5.11	5.43	5.67	6.07
	DAY 9	6.63	6.24	6.38	6.47	7.58
	DAY 10	6.94	6.98	7.06	7.59	8.23
	DAY 11	7.76	7.41	8.29	8.93	9.81
	DAY 12	9.17	8.79	9.68	9.74	10.26
	DAY 13	11.83	10.71	11.62	11.86	11.93
	DAY 14	12.18	11.09	12.38	12.98	12.67
	DAY 15	12.69	12.15	13.06	13.04	13.11
	DAY 16	13.37	13.92	14.19	14.15	14.64
	DAY 17	14.11	14.44	15.23	15.01	15.67
	DAY 18	15.02	14.98	15.77	15.82	16.34
	DAY 19	16.43	15.60	16.33	16.30	16.92
	DAY 20	16.95	16.57	17.64	17.14	17.13

Table 5: Results for group 3.(G: group, S: sample)

		GROUP 4 (75mL ACID ADDED)				
STEM LENGTHS OF SUNFLOWERS MEASURED FOR 20 DAYS (±0.1cm)		G4S1	G4S2	G4S3	G4S4	G4S5
	DAY 1	0.22	0.18	0.26	0.20	0.19
	DAY 2	0.53	0.48	0.56	0.46	0.55
	DAY 3	1.01	0.99	1.04	0.85	1.13
	DAY 4	1.83	1.86	1.93	1.47	1.94
	DAY 5	2.18	2.36	2.77	2.02	2.08
	DAY 6	3.07	3.18	3.11	3.23	2.89
	DAY 7	3.88	4.00	4.08	3.74	3.27
	DAY 8	4.43	4.91	4.96	4.17	4.55
	DAY 9	5.65	5.85	5.86	5.59	5.34
	DAY 10	6.64	6.05	6.23	6.18	6.28
	DAY 11	7.03	6.89	7.36	7.65	7.56
	DAY 12	8.14	7.66	7.78	8.34	8.14
	DAY 13	9.67	8.46	8.64	9.86	9.27
	DAY 14	10.18	10.09	10.14	10.58	10.67
	DAY 15	11.66	11.15	11.08	11.96	11.18
	DAY 16	12.24	12.37	12.15	13.16	12.62
	DAY 17	13.35	13.47	13.25	13.91	13.57
	DAY 18	14.02	14.58	14.76	15.05	14.97
	DAY 19	15.53	15.68	15.23	15.31	15.82
	DAY 20	16.05	16.27	16.62	16.61	16.33

Table 6: Results for group 4.(G: group, S: sample)

		GROUP 5 (100 mL ACID ADDED)				
STEM LENGTHS OF SUNFLOWERS MEASURED FOR 20 DAYS (±0.1cm)		G5S1	G5S2	G5S3	G5S4	G5S5
	DAY 1	0.18	0.32	0.29	0.12	0.15
	DAY 2	0.37	0.33	0.39	0.45	0.89
	DAY 3	0.96	0.94	0.98	1.54	1.09
	DAY 4	1.53	1.86	1.73	1.95	1.45
	DAY 5	1.82	1.93	2.06	2.88	2.58
	DAY 6	2.44	2.74	2.63	3.06	3.22
	DAY 7	3.68	3.83	3.27	3.91	3.82
	DAY 8	3.91	4.04	3.62	4.01	4.38
	DAY 9	4.55	4.46	4.18	4.79	4.82
	DAY 10	4.90	4.89	4.93	5.02	5.81
	DAY 11	5.94	5.62	5.91	6.16	6.15
	DAY 12	6.49	6.37	6.20	7.19	7.52
	DAY 13	7.63	7.18	7.26	7.81	7.90
	DAY 14	7.92	7.95	8.56	8.59	8.37
	DAY 15	8.46	8.91	9.13	9.49	9.40
	DAY 16	9.67	10.32	10.48	10.03	10.69
	DAY 17	10.78	10.48	11.09	10.96	11.01
	DAY 18	11.04	11.27	11.73	11.94	12.14
	DAY 19	12.85	12.91	13.08	12.92	13.68
	DAY 20	13.75	13.75	14.67	14.01	14.57

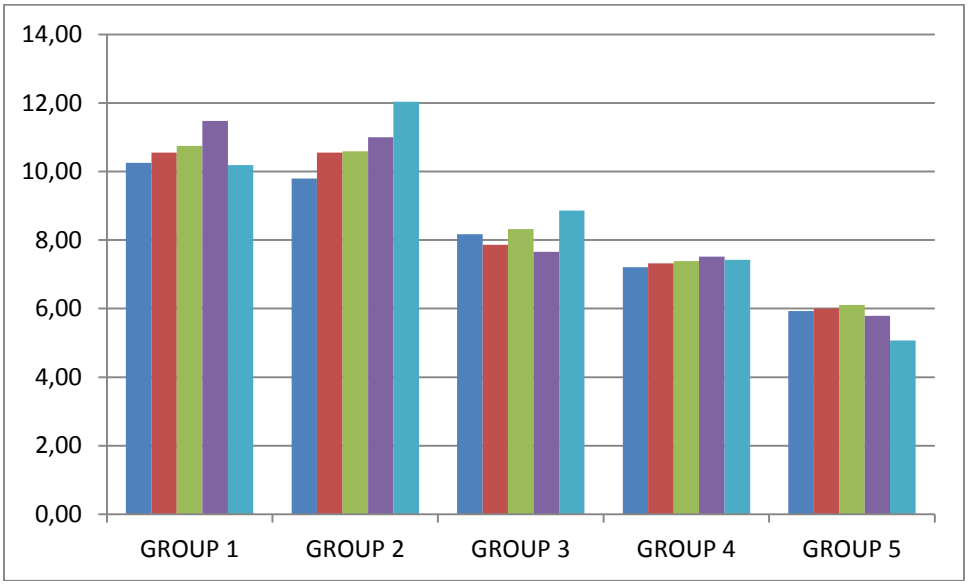
Table 7: Results for group 5.(G: group, S: sample)

MEAN STEM LENGTHS OF SUNFLOWERS MEASURED FOR 20 DAYS (±0.1cm)						
		GROUP 1 (NO ACID ADDED)	GROUP 2 (25 mL ACID ADDED)	GROUP 3 (50 mL ACID ADDED)	GROUP 4 (75 mL ACID ADDED)	GROUP 5 (100 mL ACID ADDED)
	Day1	0,29	0,31	0,23	0,21	0,21
	Day2	0,92	1,01	0,54	0,52	0,49
	Day3	1,79	1,78	1,16	1,01	1,1
	Day4	2,48	2,58	1,84	1,83	1,7
	Day5	3,97	3,46	2,58	2,28	2,05
	Day6	5,24	4,41	3,42	3,1	2,82
	Day7	6,75	5,6	4,67	3,79	3,7
	Day8	7,74	6,81	5,62	4,6	3,88
	Day9	8,69	7,64	6,66	5,66	4,56
	Day10	9,8	8,96	7,36	6,28	5,11
	Day11	11,04	10,02	8,44	7,29	5,96
	Day12	12,49	11,93	9,53	8,01	6,75
	Day13	14,62	13,9	11,59	9,18	7,56
	Day14	15,79	15,72	12,26	10,33	8,28
	Day15	16,47	16,63	12,81	11,41	9,08
	Day16	17,85	17,79	14,05	12,51	10,25
	Day17	18,63	18,85	14,89	13,49	10,83
	Day18	20,20	20,3	15,58	12,68	11,62
	Day19	21,56	21,66	16,32	15,51	13,09
	Day20	23,22	23,79	17,09	16,38	14,15

Table 8: Mean stem lengths of sunflowers. Averages of tables 3,4,5,6 and 7.

	Group 1	Group 2	Group 3	Group 4	Group 5
pH	7.2	6.5	5.4	4.6	3.8

Table 9: pH's of the soil measured in groups 1,2,3,4 and 5.



Graph 1: Graphical indication of averages.

	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
SAMPLE 1	10.25	9.80	8.17	7.21	5.93
SAMPLE 2	10.55	10.55	7.86	7.32	6.00
SAMPLE 3	10.75	10.59	8.32	7.39	6.11
SAMPLE 4	11.48	11.00	7.66	7.52	5.79
SAMPLE 5	10.19	12.04	8.86	7.42	5.07

Table 10 :Table shows the averages for 5 samples for each 5 group.

MEAN	10,64	10,80	8,17	7,37	5,78
MEDIAN	10,55	10,59	8,17	7,39	5,93
RANGE	1,29	2,24	1,20	0,31	1,04
VARIANCE	0,27008	0,67103	0,21368	0,01337	0,171
SD	0,519692217	0,819164208	0,462255341	0,115628716	0,413521463
SE	0,232413425	0,366341371	0,206726873	0,051710734	0,18493242
T	2,776445105	2,776445105	2,776445105	2,776445105	2,776445105
%95 Cl (SEXT 0,05 DT)	0,645283115	1,017126706	0,573965814	0,143572014	0,513454713
%95 Cl (EXCEL)	0,455521942	0,718015893	0,405177226	0,101351176	0,362460883

Table 11: Descriptive statistics of the datas shown in the table 9.

Anova: Single Factor

Summary

Groups	*Count*	*Total*	*Mean*	*Variance*
GROUP 1	5	53,22	10,644	0,27008
GROUP 2	5	53,98	10,796	0,67103
GROUP 3	5	40,87	8,174	0,21368
GROUP 4	5	36,86	7,372	0,01337
GROUP 5	5	28,9	5,78	0,171

ANOVA

Variance Source	*SS*	*df*	*MS*	*F*	*P-vaue*	*F criteria*
Between Groups	93,156304	4	23,289076	86,95404582	2,36248E-12	2,866081402
In groups	5,35664	20	0,267832			
Total	98,512944	24				

Table 12: ANOVA test applied on the datas shown in the table 9.

CONCLUSION AND EVALUATION

My purpose in this experiment was to investigate the effect of sulphuric acid to the growth of *Hellianthus annuus* (Sunflower).

5 groups are present in the experiment which 0, 10, 25, 50 and 100 mililiters of sulphuric acid (H_2SO_4) mixed with 1 liter of water. Each 10 ml of the solutions have 0, 0.25, 0.50, 0.75, and 1.00 mililiters of sulphuric acid respectively. Once for every two days the plants were watered at 20:00 with using 10 mL water with varying acid solution. The plants were watered using an injector and datas collected daily for each group which are shown in Table 3, 4, 5, 6 and 7.

The average heights of the plants found 10.64, 10.80, 8,17, 7.37, 5.78 respectively. See table 11 for results.

Anova test applied to correctly evaluate the data. Shown in table 12. This evaluation can be done by looking at the P-value which is found a smaller than the α value.

α = 0.05 > P-value = 2,36248E-12

P value is smaller than the alpha value (0.05). It shows that there is a statistically considerable mean difference between groups. So, H_1:Different concentrations of sulfuric acid solutions will affect the growth rate of *Hellianthus annuus* (Sunflower) is accepted. H_0: Different concentrations of sulfuric acid solutions will not affect the growth rate of *Hellianthus annuus* (Sunflower) is rejected

By looking at the average heights of the plants shown in Table 11, one can see that group 2 shows more growth than group 1 in average. Also in the pH scale given (Table 9) it seems that pH 6.8 is a more suitable choice. As I said in my hypothesis part (page 7) if the pH of the soil drop below 5.5 soil cannot neutralise the acidity. Therefore pH 6.8 can be neutralized by soil so it cannot be considered as acidic.

Although result testifies the hypothesis there are several reasons for possible errors. Sunflowers (*Hellianthus annus*) are photoautotrophs. Light energy is converted to chemical energy and used to produce organic compounds in the

process of photosynthesis. So photosynthesis is very important step for the rate of plant growth. As a result plant growth is also affected by factors that affect photosynthesis. The number of light photons hitting the chlorophyll pigments increase as the light intensity rises. This also increases the rate of photosynthesis. More light means more energy. In the experiment approach of sunlight photons may be sligthly different for groups. Samples may have recieved light rays from different angles. Therefore, the energy they received may not be equal so it affects photosynthesis and the growth rate.

Interference of any microorganism is also a major source of error. Although all conditions were tried to be same for all plants, it is also possible that microorganisms have been produced in any of the plant pots. These organisms may have prevented the development of the plant.

Another source of error could be genetic variance because genes and environmental conditionsdetermine the growth ofthe plant, photosynthesis rate, hormone production and their management. All these factors affect growth of the plant.

In order to eliminate errors some improvements could be done. For example performing the experiment in the natural environment could have increased the accuracy of the results. The experiment done on large numbers of plants would reflect the agricultural effects of sulfuric acid better. So, there are a variety of ways by which the experiment can be improved, resulting in more accurate and precise data.

To sum up graph drawn and applied ANOVA test shows as sulfuric acid concentration increases the growth of the plant is inhibitted. The research question was "How is the growth of *Helianthus annuus* (Sunflower) in terms of height (cm) effected by different concentrations of sulfuric acid (H_2SO_4) solutions added to different groups while the soil quality, temperature and pressure is tried to be constant for all groups?" for this experiment. The descriptive statistics of the datas collected that shown in Table 11 and ANOVA test applied in Table 12 supports the main hypothesis which is **H_1:Different concentrations of sulfuric acid solutions will affect the growth rate of *Helianthus annuus* (Sunflower).** It appears that acid had a negative effect on sunflower growth. Aciditiy cause the growth of the plant to be stunted. Nutrients present in the soil, are destroyed by the acidity, resulting in less nutrients being available for the plants.

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