***Abstract***

Does Caffeine Influence Metabolism of Plants?

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This project will show the influence of caffeine on certain plants. The initial idea was to see if caffeine would speed up the growth of plants by influencing its metabolism. Instead of regular water plants are being watered with caffeine solutions containing different percentages of caffeine in it.

Radish plants are being used as the test organisms. The effective caffeine concentrations are – 25%, 50%, 75%, and a 100%. The controlled samples are being watered with regular water.

The plants are growing in the greenhouse at school. The temperature increase in the recent days helped a lot – plants started to grow better, because the soil is not freezing any more.

The data for two weeks have been collected, and the whole project will take 6 weeks total. There wasn’t much change in the growth of plants yet. During the next 5 weeks I will be collecting data from the plants, compare it to the data collected from the same plants from the previous weeks and compare the data collected from the plants that grow in caffeine-free environment to the data collected from the plants that grow with caffeine in their soil. All the information will be recorded, analyzed, and described in the conclusion.

***Introduction:***

My family drinks coffee every morning, because it gives them energy and “wakes them up”. I drink coffee at least once a day, and I am really amazed how much energy this wonderful drink gives me. Of course, I understand that if I will take too much, it will have negative effect on me. But until then…I enjoy a cup of coffee, so I can go to school cheerful and full of energy.

“*Caffeine was discovered in 1820. It is an alkaloid and belongs to the methylxanthines group. Caffeine is found in guarana, kola nuts, coffee, tea, cocoa beans, mate and other plants. Caffeine is the most popular drug on the globe. It is a power and energy accelerant for human body. It is a powerful stimulant to the Central Nervous System”[[1]](#footnote-0)1.*

If you think about it, caffeine affects different people in many different ways. For example – many people think that it is not good for kids. Maybe because they are growing organisms and they need healthy diet? And caffeine doesn’t carry a supply of certain vitamins. People start drinking coffee from one cup a day in the morning and then in a few months they are already addicted to it, and can’t function properly without taking it. The described above things are very common points of view of most of the people. Why do we know so little about the effect of coffee on other living organisms? Scientists are doing experiments, discover things, publish them – but if to ask an average person about the effect of caffeine on animals and plants – not many of them would be able to answer this question. Animals, plants, fish, mushrooms, plankton and so on? Isn’t it interesting to know what affect can caffeine cause on different creatures, if have an effect at all. Let’s take for example plants. Caffeine is not an essential nutrient, so we would think that it wouldn’t influence plants at all. But caffeine is not an essential nutrient for humans either, but still, it has huge effect on human metabolism system. So, why not to make an experiment and know for sure if caffeine is influencing plants or not. Let’s say that we’ve decided to make an experiment. The first step than will be to make a good search on “caffeine” and “plants” topics, as well as “caffeine and plants” together. All the information that could be found may be interesting and useful for the experiment that I am going to make.

“*The caffeine is not just a stimulant, but it reaches deep into the muscle cell to provide lasting power and delaying the onset of muscle fatigue. Caffeine affects CNS (Central Nervous System) causing more alertness and allowing for more intense focus. The chemical structure of caffeine is very similar to that of adenine (a component of ATP, DNA, and cyclic AMP). Only the substituents are different. This helps explain caffeine’s stimulating effects. Because of the structural similarities, caffeine can slip right into adenosine receptors, keeping cyclic AMP active rather than it being broken down. When cyclic AMP breaks down, the body’s energy supply decreases. Because caffeine fools the body into using enzymes to break it down, the cyclic AMP supply remains higher for longer. Nobody really needs caffeine, but if all of America were stop drinking coffee or caffeine-containing soft drinks/beverages, productivity would fall by 70%. So, for more alertness and mental/physical boost a little caffeine can be used safely. Also – deficiency is not an associated problem with caffeine because it is not an essential nutrient”*[[2]](#footnote-1)2.

If a molecule of caffeine is similar to the one of adenine, then it is a very important factor for us to know because if caffeine will help plants to grow (which will be my hypothesis) then we will know that one of the factors that helps it to grow is that caffeine will provide enough adenine-similar molecules in the plant that can be used by the plant so the plant wouldn’t have to look for adenine if it needs some, it will just use the given caffeine molecules to take a good care of its DNA and ATP.

“*Caffeine increases the level of circulating fatty acids. This has been shown to increase the oxidation of these fuels, hence enhancing fat oxidation. Caffeine has been used for years by runners and endurance people to enhance fatty acid metabolism. It's particularly effective in those who are not habitual users”*.[[3]](#footnote-2)3

Certainly plants are not use to take caffeine solution instead of regular water that can be found in the soil (for example - grasses, trees, bushes – all take water from the soil, unless it is a specially grown plant that is being watered with some special solution). Caffeine would be something new if to introduce it to plants. The webpage that is above quotation is taken from says that caffeine is particularly effective in those who are not habitual users. Plants are not “habitual users”. Would it be right to assume that the caffeine solution is going to effect plants stronger if they would be watered with tap water and then suddenly with caffeine solution? That would be an appropriate thing because if I was to start watering the seeds, that I have just planted, with a caffeine solution, then if they won’t grow, I will not know if it’s the caffeine solution that I am watering them with or something else. Therefore, it is better to water them with tap water first, and then when they will grow I can water them with caffeine solutions and by collecting data every week, I will see what comes out of the experiment – whether plants will grow and have obvious variations from concentration to concentration, or they will not vary at all. The controlled plants will be kept being watered with a regular water, so the collected results can be compared with one another : no-caffeine solution with different %-ages of caffeine concentrations.

“*The biochemical effect of caffeine on plants (and animals) is well known, so much so that caffeine is often used as a tool to investigate processes affecting a variety of cell functions. Caffeine is a calcium release inducer. That means that adding caffeine to cells causes internal calcium to be released. This can result in a wide array of effects as calcium is used in plant cells for a number of purposes. The well-defined action of caffeine makes it useful, because basically, if you see an effect when caffeine is added, the effect is presumed to involve calcium release and/or membrane permeability. For example, recent literature investigating haptonema coiling and cellular differentiation used caffeine to identify calcium efflux and permeability changes as playing a role in these plant processes. Another apparent affect of caffeine on plants may be a role in UV protection. This effect may be mediated through calcium as well. All plants have a requirement for calcium which affects the permeability and organization of membranes. Calcium is also required by alpha-amylase, an enzyme involved in the hydrolysis of starch. Calcium can be used for detoxifying oxalic acid, which becomes insoluble and non-toxic to the plant protoplasm when calcium is bonded onto the acid. Some algae deposit calcium externally, as a by-product of obtaining carbon dioxide for photosynthesis, and are responsible for a large proportion of reef-building. Adding caffeine in appropriate doses would lead to symptoms similar to calcium deficiency including stunted growth. (Not mentioning that adding caffeine, or anything else, in high doses could result in more immediate toxic effects. For example, caffeine solutions may be overly acidic, so that the result seen is a pH effect, rather than a direct effect of caffeine. These potential problems must all be taken into consideration in designing the experiment.) Calcium deficiency is seen in plants as a general disorganization of cells and tissue, which is consistent with its role in membrane organization. Growing tips may be* *particularly affected resulting in stunted growth of leaves and roots because calcium is poorly transported from older to younger shoots. Both effects are reflected in the general health of the plant which may succumb to a variety of diseases as secondary infections take hold. For example, blossom-end rot in tomato fruit is often attributed to calcium insufficiency. Caffeine application is likely to mimic these effects.”*[[4]](#footnote-3)4

Here we can see a scientific explanation of results that caffeine causes in plants. If plants wold need calcium, they can use caffeine molecules if we were to water them with caffeine solution. Caffeine molecules might react with the molecules in plants in the same way as calcium would do. In this way the plant will not need to use calcium, because it will have enough supply of caffeine molecules.

“*There was a paper published some time ago which suggests caffeine inhibits the process of* ***cytokinesis*** *in plant cells - the last part of mitosis where the two daughter cells split their cytoplasm and organells before a cell wall forms to fully separate them.”*[[5]](#footnote-4)5

Putting caffeine in the soil might make it difficult for cells to divide, and it may require more energy for the cells to divide. And if it will slow down the rate of cell division, maybe the roots will be not very long. The good side of it is that if the roots will not be very long that we can grow plants in small pots and their roots will have enough space for them to grow and not form a huge bundle. On the other hand – the leaves may not grow large enough and the plant will be doing poor. Also – the roots will not have enough surface area for the plant to absorb the nutrients it needs. But let’s not forget the structure of caffeine molecule – it is close to the one of adenine, and it might give the plant a lot of energy – for the process of making ATP and for DNA structure – 2 main things in the life of plant.

“*Regarding* ***methylxanthines*** *- a family of chemicals of which caffeine is a member. Many plant-dervied methylxanthines function as antimicrobial factors and naturally-occuring insecticides.”*[[6]](#footnote-5)6

That is a good thing because we all want our plants to be protected from all the diseases and insects that may cause the plant’s development to slow down. We don’t want the plant to waste energy on putting forces on recovering from the damage caused by the insects or recovering from diseases – especially the fruits and vegetables – we don’t want our food to have any diseases in it. The best way would be if the plants would not have any damages at all. So if we will put the caffeine solution in the soil – it might protect plants from certain things that we don’t want it to have.

“*Caffeine increases growth of Rye Grass – plant growth increases with the use of coffee as the hydrating element vs. the use of ordinary tap water.*”[[7]](#footnote-6)7

The quote above shows that someone have already done a research on the growth of Rye grass and the results showed that it grows better with caffeine. If I will make an experiment by myself, I will know for sure if watering plants with caffeine will help them to grow or will not have a great impact on their growth.

“*Studies show that plants watered with caffeinated coffee grow better than control plants watered with water.”*[[8]](#footnote-7)8

This statement just supports the one made before – it shows that someone made an experiment on watering plants with caffeine solution and the results appeared to be so that caffeine really does influence the growth of plants in a positive way.

“*There are two thoughts on the idea, but no one really knows for sure. One study (Frischknect et.al. 1985) believes that caffeine protects plants from insect or fungal attacks. Another study (Friedman & Waller 1983) believes that caffeine excreted by the plant into the soil surrounding it reduced growth of competing plants and bacteria.”*[[9]](#footnote-8)9

Here is another opinion about protection of plants from insects by putting caffeine in the soil. It is already second time I meet this kind of statement during my search on “caffeine and plants” topic. But my area will cover the influence of caffeine on metabolism of plants – exactly how tall they grow and how large their leaves will grow, to see if caffeine makes plants grow larger. After completing my experiment I can investigate other branches in this area, for example – to see if adding caffeine to the soil changes the amount of insects that live on the given plant. But then I will have to choose some plant that is being damaged by insects a lot – like potato or tomato, so my experiment will show if plants that are grown in caffeine solution will be damaged less than the ones being watered with a regular water.

As you can see, there are many interesting things about caffeine influencing plants. Then, why not to investigate it? Indeed, if I will have a successful experiment ant it will appear that plants grow better when I water them with caffeine solutions rather than with regular water, then we can be watering plants with caffeine, and get much higher harvests on our fields, expand our economy in some way, and moreover – expand our knowledge in the field of metabolism of plants. Further we can investigate why caffeine causes similar effects on metabolism of plants as it does on metabolism of humans, and what do humans and plants have in common that caffeine is so much attracted to? On the other hand – if my experiment will show that caffeine doesn’t make plants grow better, but makes them die, we will know for sure that there in no use of watering plants with caffeine, because it will just kill them.

Summarizing all the information discovered during the search, we can see the clear outline:

* molecule of caffeine is similar to the one of adenine, which is found in DNA and ATP – two very important components of the plant life
* molecule of caffeine replaces the molecule of calcium and could be used instead of calcium to cause similar effect on plants as calcium does
* protection of plants from insects and diseases by adding caffeine to the soil

Therefore, we can use caffeine as a part of a fertilizer. It could be an expensive

fertilizer, but there is always a way to work things out. For example – used coffee still has some caffeine in it and if it can be added to the fertilizer, it will be not that expensive. If my experiment will support my hypothesis, then we could get a lot more from our harvests. Of course then we would have to study all the side effects, because each plant is individually unique, and it doesn’t mean that if it has a good effect on one plant, then it will have a good effect on any plant.

After some analysis I have started an experiment. I chose to use *brewed coffee* because the caffeine content in it is not very large *(80-135)* in compare with *espresso (100) and drip (115-175)* . In brewed coffee the 25% solution of it will be relatively small and not as large as if I would of chosen the coffee that has huge caffeine content in it and 25%, 50%, 75% and 100% caffeine solutions of it would be still very strong for plants – making it too much. But 25% of brewed coffee will be different from the 50% and so on. I don’t really know which concentration will be effective, so I chose four different concentrations: 25%, 50%, 75% and 100%. Noting that the coffee I chose – “*Columbia Supreme” has 1.37% caffeine in its beans and blends.”*[[10]](#footnote-9)10

I took 50 mg of coffee and 500ml of water and made brewed coffee, and counted the proportion 50mg/500ml as 100%. Then by adding water I was able to get other concentrations, like – 25%, 50%, and 75%. The controlled plants should be grown without caffeine in it, so I will have data to compare it with. The only changing variable is that plants are being watered with different caffeine concentration solutions, and the controlled ones are taking water. The rest of them are the same unchangeable conditions. Each sample size contains 10 pots with plants that all get the same amount of hydrating solution. The 25% ones have 16 pots and each one of them gets the equal share of watering solution. The radish was chosen to be the object of an experiment because it is a fast growing plant and it is a vegetable – so the experiment can be of use – fertilization of the soil. The seeds are 2-3 mm long, were planted, and within a certain amount of time when the plants reached a certain height, I started to water them with caffeine solutions. The coffee was kept closed in a dry place, to prevent it from spoiling, and fresh coffee was made every week so it is always fresh for plants and it was kept in plastic bottles. The project itself will take 5 weeks - 5 times of data collection, and the results will be carefully examined, recorded, analyzed and discussed in class with the students and the teacher.

In my project I want to see if caffeine really does influence the growth rate of plants, and if it does, then how does it influence it. Also – all the other noticed changes in plants will be recorded, so they can be investigated further in other experiments.

***Hypothesis/Prediction:***

**Hypothesis:**

Caffeine will increase rate of growth in plants.

**Prediction:**

If caffeine will increase rate of growth in plants, then by watering plants with various caffeine solutions we will notice the difference in growth rates of plants being watered with caffeine and without caffeine.

# ***Experiment Procedure:***

**Materials:**

* pots
* soil
* ruler with “cm” measurements
* bottle with “ml” measurements
* water
* coffee to make caffeine solution
* thermometer
* radish seeds
* computer, paper, pencils

**Data:**

**“No caffeine” solution – regular water**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Amount of radish plants in a tray** | **Amount of large leaves** | **Amount of medium leaves** | **Amount of small leaves** |
| #1 | 2 | 4 | 4 | no,1 newborn |
| #2 | 2 | 4 | 4 | no |
| #3 | 5 | 10 | 8 | no, 4 newborn |
| #4 | 5 | 10 | 10 | no |
| #5 | 4 | 9 | 7 | no |
| #6 | 5 | 8 | 11 | 1, 1 newborn |
| #7 | 3 | 9 | 1 | 1, 1 newborn |
| #8 | 4 | 4 | 5 | 7 |
| #9 | 4 | 9 | 6 | 1 |
| #10 | 4 | 6 | 10 | no |

**Week #1**

On the same basis data will be collected every week. Instead of making a huge table the results will be analyzed and the average will be recorded during the procedure. Further the tables will be showing just the average results of data collection. The table above just shows **how** the data is being collected.

The leaves have green color, and their stems have a pale green color. The table

below shows the average width and length of the leaves:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 1.72 cm | 2.03 cm |
| Medium Leaves | 1.49 cm | 1.20 cm |
| Small Leaves | 1 cm | .7 cm |
| Newborn Leaves | .65 cm | .5 cm |

**The average high of plants is 4.08 cm.**

Totaling all the information above we can see that there is:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the non – caffeine samples** |
| Large | 73 |
| Medium | 66 |
| Small | 10 |
| Newborn | 7 |

As we can see, the amount of large leaves is the biggest and then goes the medium category, while small and newborn leaves make up a very little percentage of the whole amount of leaves. What I can suggest is that the newborns #1 grow up, and when they reach medium size, a new pair of leaves starts to grow – newborns #2. Meanwhile the newborns #1 go from medium size to a large size, while the newborns #2 reach medium size, and then newborns #3 show up. So, reaching medium size for one pair of leaves will lead to the birth of new pair of leaves. Maybe that is why there are not very many newborns and small leaves – because the plants were planted at the same time and their leaves are reaching the medium size at the same time, and then the newborns will start to grow ones the current leaves will reach the medium size. The plants that are growing faster or slower than average growth rate are performing small leaves and newborns.

## **Week#2**

Data is collected on the plants, the results are shown below in the table:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the non – caffeine samples** |
| Large | 57 |
| Medium | 61 |
| Small | 39 |
| Newborn | 15 |

This might seem unusual – less large leaves than was before? But remember – the size of the leaves is determined in relation to the size of other leaves in a tray – if all of them are relatively small, the largest ones will be called “large” size.

Lets talk about the leaves of the radish. The first couple of leaves as I have noticed doesn’t grow very well, they grow to a certain height, and then stay the same size, while the leaves of the second set are growing really well. So, the amount of 57 large leaves instead of 73 that we had before should tell us that some leaves that were counted as large before are not large any more in compare with the rest of the leaves – they stayed about the same size while the second pair of leaves grew up and reached the size larger than those first leaves, so now they are counted as large, and the previous large ones counted as medium in compare with the new ones that grew so high. And since there are so many medium sized leaves, more newborns and small leaves can be seen. Below you will see the table with average length of the leaves:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 2.32 cm | 1.78 |
| Medium Leaves | 1.6 cm | 1.8 cm |
| Small Leaves | 1.5 cm | 1.56 cm |
| Newborn Leaves | 1 cm | .93 cm |

**The average height of the plants is 5.3 cm.**

**Week #3**

All of the result are shown below in the tables.

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the non – caffeine samples** |
| Large | 21 |
| Medium | 4 |
| Small | 19 |
| Newborn | 15 |

Because of the drying out on the 30th, the non-caffeine ones were damaged the most and they are recovering , that is why we can’t observe large amounts of the medium size leaves. But the dry (or dead) medium size leaves make up an amount of 24. So that is why there are many small and newborns. I would say it is because there were a lot of medium and so newborns were born and later became the small ones. And after a lot of medium leaves died out, a lot of newborns appeared. The leaves that died didn’t need the water and nutrients from the soil, so it all went to make a newborn leaves – to recover. Four out of 10 pots weren’t damaged at all. So the successful data can still be collected.

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 3.36 cm | 2.22 cm |
| Medium Leaves | 2.75 cm | 1.95 cm |
| Small Leaves | 2.05 cm | 1.35 cm |
| Newborn Leaves | 1.05 cm | .48 cm |

**The average height of the plants is 6.78 cm.**

## **Week #4**

## **The results are below in the tables.**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the non – caffeine samples** |
| Large | 12 |
| Medium | 30 |
| Small | 17 |
| Newborn | 30 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 3.7 | 2.45 |
| Medium Leaves | 2.95 | 1.9 |
| Small Leaves | 2.08 | 1.38 |
| Newborn Leaves | 1.2 | .88 |

**The average height of plants is 6.94 cm.**

**Week #5**

All the data is shown below in the tables.

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the non – caffeine samples** |
| Large | 22 |
| Medium | 32 |
| Small | 42 |
| Newborn | 25 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 3.81 | 2.55 |
| Medium Leaves | 2.98 | 1.93 |
| Small Leaves | 2.28 | 1.45 |
| Newborn Leaves | 1.07 | .8 |

**The average height of plants is 7.07 cm.**

The temperature and humidity were measured at the beginning of each week:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Weeks of watering with caffeine:** | **Minimum temperature of the Week** | **Maximum temperature of the Week** | **Humidity when the temperature was minimum** | **Humidity when the temperature was maximum** |
| #1 | 1ْC | 51ْC | 53% | 55% |
| #2 | 1ْC | 51ْC | 43% | 43% |
| #3 | 1ْC | 51ْC | 54% | 56% |
| #4 | 1ْC | 51ْC | 44% | 44% |
| #5 | 1ْC | 51ْC | 73% | 74% |

**25% Caffeine Solution.**

The seeds that I am watering with the 25% solution were planted on the 19th of January, 2001 - way before the rest of my samples. They have survived while others either died or did not show up at all. To have more data for my project and to not through away the live plants, I’ve decided to still use them for the project while the rest of the radish was replanted. The “25% solution” plants before I’ve started watering them with caffeine remained of the same average height for a month or so after they grew up to the certain height. The table below shows the amount of leaves on each plant, as well as the sizes of the leaves and the amount of plants in each pot on the day that I have started my project - the 20th of March, 2001:

**Week #1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tray with a plant** | **Amount of radish plants in a tray** | **Amount of large leaves** | **Amount of medium leaves** | **Amount of small leaves** |
| #1 | 1 | 5 | 1 | no |
| #2 | 1 | 4 | 2 | no |
| #3 | 1 | 1 | 3 | 1 newborn |
| #4 | 1 | 4 | 1 | no |
| #5 | 1 | 2 | 3 | 1 newborn |
| #6 | 1 | 4 | 1 | 1 |
| #7 | 1 | 4 | 1 | 1 newborn |
| #8 | 1 | 4 | 2 | 1 newborn |
| #9 | 1 | 5 | 1 | no |
| #10 | 1 | 5 | 1 | no |
| #11 | 1 | 4 | 2 | 1 newborn |
| #12 | 1 | 3 | 2 | 1 newborn |
| #13 | 1 | 5 | 1 | no |
| #14 | 1 | 4 | 2 | 1 newborn |
| #15 | 1 | 5 | 1 | 1 newborn |
| #16 | 1 | 3 | 3 | no |

The table above shows **how** the data is being collected. Further on the tables will be showing only the average of the data collected from the plants. That way the difference will be seen more clearly between the data of different weeks. And the table above is an explanation of how I am collecting the data.

Looking at the data after a week of watering them with a “25% solution” we can see if the rate of their growth is big in compare with the rate of growth of other plants that are being watered with different caffeine solutions.

The leaves have green color and their stems have a dark pink color. Table below

shows the average width and length of the leaves.

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 25 % caffeine samples** |
| Large | 59 |
| Medium | 27 |
| Small | 1 |
| Newborn | 8 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 4.18 cm | 3.25 cm |
| Medium Leaves | 3.45 cm | 2.3 cm |
| Small Leaves | 1.93 cm | 1.56 cm |
| Newborn Leaves | .95 cm | .56 cm |

**The average high of plants is 7.36 cm.**

The table above shows us that there are many large leaves, not as many medium

size leaves almost no small ones (could be explained by medium leaves to be just

reaching its medium size and therefore the newborns are just showing and will start to grow to become small and turn into medium and then big).

**Week #2**

The results of data collection are shown below in tables:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 25 % caffeine samples** |
| Large | 29 |
| Medium | 35 |
| Small | 26 |
| Newborn | 7 |

Almost the same results were observed in the plants that have no caffeine in the soil. The medium size leaves grew larger, the newborns appeared, and now they have reached small size, while medium ones grew even larger. Some newborns appeared as well, but not many in compare with the whole size of the sample.

The average length and width of the leaves of the week #2 data collection you can see below:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 5.22 cm | 3.55 cm |
| Medium Leaves | 3.92 cm | 2.5 cm |
| Small Leaves | 3.2 cm | 2.24 cm |
| Newborn Leaves | 1.42 cm | 1.2 cm |

**The average height of plants is 10.74 cm.**

**Week #3**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 25 % caffeine samples** |
| Large | 37 |
| Medium | 55 |
| Small | 34 |
| Newborn | 15 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 6.23 cm | 4.15 cm |
| Medium Leaves | 4.05 cm | 3.05 cm |
| Small Leaves | 3.3 cm | 2.6 cm |
| Newborn Leaves | 1.47 cm | 0.77 cm |

**The average height of the plants is 11.26 cm.**

**Week #4**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 25 % caffeine samples** |
| Large | 33 |
| Medium | 67 |
| Small | 29 |
| Newborn | 44 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 6.38 cm | 4.28 cm |
| Medium Leaves | 4.28 cm | 3.03 cm |
| Small Leaves | 2.83 cm | 2.43 cm |
| Newborn Leaves | 1.53 cm | 1.23 cm |

**The average height is 22.62 cm.**

**Week #5**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 25 % caffeine samples** |
| Large | 38 |
| Medium | 55 |
| Small | 37 |
| Newborn | 33 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 7.10 cm | 4.43 cm |
| Medium Leaves | 4.63 cm | 3.58 cm |
| Small Leaves | 3.28 cm | 2.38 cm |
| Newborn Leaves | 1.63 cm | 1.13 cm |

|  |  |
| --- | --- |
| **The average height of plants is 33.86 cm.** The temperature: **Weeks of watering with caffeine:Minimum temperature of the weekMaximum temperature of the weekHumidity when the temperature was minimumHumidity when the temperature was maximum**#11ْC51ْC53%55%#21ْC51ْC43% | 43% |
| #3 | 1ْC | 51ْC | 54 % | 56% |
| #4 | 1ْC | 51ْC | 44% | 44% |
| #5 | 1ْC | 51ْC | 73% | 74% |

**“50% Caffeine” Solution**

## **Week #1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tray with a plant** | **Amount of radish plants in a tray** | **Amount of large leaves** | **Amount of medium leaves** | **Amount of small leaves** |
| #1 | 1  1 | 2  2 | 2  2 | No  No |
| #2 | 1  1 | 3  2 | 1  1 | No  1 |
| #3 | 1  1 | 4  no | No  4 | 1  no |
| #4 | 1  1  1  1 | no  2  3  no | no  2  1  no | 4  1 newborn  no  4 |
| #5 | 1  1  1 | 2  2  no | 2  2  no | no  no  4 |
| #6 | 1  1 | 3  2 | 1  1 | no  1 |
| #7 | 1  1  1  1 | 1  1  no  2 | no  1  3  2 | 1 newborn  1 newborn  no  no |
| #8 | 1  1 | 4  no | no  1 | 1 newborn  3 |
| #9 | 1  1 | 2  2 | 2  2 | No  no |
| #10 | 1  1  1 | 2  3  4 | 2  1  no | no  1 newborn  no |

The table above shows **how** the data is being collected. Further on the tables will be showing only the averages of the data collected from the plants. So it will be easier to see the difference in the results of plant growth during the different weeks.

Totaling all the information above we can see that there is:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 50 % caffeine samples** |
| Large | 48 |
| Medium | 33 |
| Small | 18 |
| Newborn | 5 |

The leaves have green color and the stems have pale green color. The table below shows the average width and length of the leaves:

|  |  |  |
| --- | --- | --- |
| **Size of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 2.26 cm | 2.4 cm |
| Medium Leaves | 1.6 cm | 1.85 cm |
| Small Leaves | 1.05 cm | 1.16 cm |
| Newborn Leaves | .52 cm | .43 |

**The average height of plants is 3.83 cm.**

The acquired data is similar to the data from non – caffeine and 25% solution plants. The leaves reached the medium size and newborns appeared, now they grew up to small size, and a very few newborns can be observed.

### **Week #2**

The results are shown below in the table:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 50 % caffeine samples** |
| Large | 41 |
| Medium | 50 |
| Small | 10 |
| Newborn | 5 |

My explanation for the data above would be that the small plants grew up to the medium size and the newborns appeared, but that they are still in process of appearing, because there is not that many small leaves. And I am going to think that during the next several days the amount of newborns will increase to continue the increase in the amount of the new pairs of leaves that appeared after the first set of small ones reached medium size.

Below you will see the table with average length and width of the leaves:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 2.96 cm | 2 cm |
| Medium Leaves | 1.43 cm | 1.8 cm |
| Small Leaves | 1.77 cm | 2.1 cm |
| Newborn Leaves | .86 cm | .6 cm |

**The average height of plants is 6.45 cm.**

**Week #3**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 50 % caffeine samples** |
| Large | 36 |
| Medium | 57 |
| Small | 41 |
| Newborn | 23 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 4.73 cm | 3.53 cm |
| Medium Leaves | 3.5 cm | 2.55 cm |
| Small Leaves | 2.4 cm | 1.83 cm |
| Newborn Leaves | .76 cm | .5 cm |

**The average height of plants is 8.56 cm.**

**Week #4**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 50 % caffeine samples** |
| Large | 38 |
| Medium | 49 |
| Small | 29 |
| Newborn | 25 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 5.08 cm | 3.70 cm |
| Medium Leaves | 3.83 cm | 2.63 cm |
| Small Leaves | 2.63 cm | 1.55 cm |
| Newborn Leaves | 1.30 cm | 1.15 cm |

**The average height of plants is 8.73cm.**

**Week #5**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 50 % caffeine samples** |
| Large | 37 |
| Medium | 46 |
| Small | 27 |
| Newborn | 22 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 4.95 cm | 3.83 cm |
| Medium Leaves | 3.48 cm | 3.00 cm |
| Small Leaves | 2.33 cm | 1.95 cm |
| Newborn Leaves | 1.23 cm | .90 cm |

**The average height of plants is 8.98 cm.**

The temperature and humidity are measured at the beginning of each week:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Weeks of watering with caffeine:** | **Minimum temperature of the week** | **Maximum temperature of the week** | **Humidity when the temperature was minimum** | **Humidity when the temperature was maximum** |
| #1 | 1ْC | 51ْC | 53% | 55% |
| #2 | 1ْC | 51ْC | 43% | 43% |
| #3 | 1ْC | 51ْC | 54 % | 56% |
| #4 | 1ْC | 51ْC | 44% | 44% |
| #5 | 1ْC | 51ْC | 73% | 74% |

**“75% Caffeine Solution”**

## **Week #1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tray with a plant** | **Amount of radish plants in a tray** | **Amount of large leaves** | **Amount of medium leaves** | **Amount of small leaves** |
| #1 | 1 | no | No | 7 |
| #2 | 1  1  1 | 3  4  no | 1  no  2 | no  no  2 newborn |
| #3 | 1  1  1 | 2  no  1 | no  2  2 | 1 newborn  2 newborn  1 newborn |
| #4 | 1  1 | 2  no | no  2 | no  2 newborn |
| #5 | 1  1  1 | 4  2  no | no  no  2 | no  2  2 newborn |
| #6 | 1  1 | 2  2 | no  2 | 1newborn  no |
| #7 | 1  1  1 | no  no  no | 4  4  4 | No  No  no |
| #8 | 1  1  1  1 | 1  1  2  no | 1  1  no  2 | No  no  1 newborn  1 newborn |
| #9 | 1  1 | 4  2 | no  no | no  no |
| #10 | 1  1  1 | 2  3  no | No  No  2 | 2 newborn  1 newborn  2 newborn |

The table above shows **how** the data is being collected. Further on the tables will be showing only the average of this data, because in this way it is much easier to see the difference in plant conditions variations from week to week.

The leaves have green color and the stems have a pale green color. The table below shows the average width and length of the leaves:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 1.86 cm | 2 cm |
| Medium Leaves | 1.43 cm | 1.15 cm |
| Small Leaves | 1.2 cm | .85 cm |
| Newborn Leaves | .54 cm | .43 cm |

Totaling all the information above we can see that there is:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 75 % caffeine samples** |
| Large | 37 |
| Medium | 31 |
| Small | 9 |
| Newborn | 18 |

The information above shows us almost what we have observed in the previous samples. 31 leaves reached its medium size and 18 newborns showed up.

**The average height of plants is 4.1 cm.**

## **Week #2**

The results are shown below in the table:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 75 % caffeine samples** |
| Large | 36 |
| Medium | 35 |
| Small | 23 |
| Newborn | 9 |

All the newborns grew to the small size, but some newborns are still showing up, not in a large amounts though in compare with the total number of leaves.

Below you will see the table with average length of the leaves:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 2.77 cm | 1.7 cm |
| Medium Leaves | 1.73 cm | 2.03 cm |
| Small Leaves | 1.46 cm | 1.66 cm |
| Newborn Leaves | 1.15 cm | .9 cm |

**The average height of plants is 6.93 cm.**

**Week #3**

The results are below in the tables:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 75 % caffeine samples** |
| Large | 35 |
| Medium | 56 |
| Small | 52 |
| Newborn | 17 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 4.35 cm | 3.25 cm |
| Medium Leaves | 3.58 cm | 2.63 cm |
| Small Leaves | 2.35 cm | 1.83 cm |
| Newborn Leaves | 1.1 cm | .6 cm |

**Average length of leaves is 9.43 cm.**

**Week #4**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 75 % caffeine samples** |
| Large | 33 |
| Medium | 46 |
| Small | 27 |
| Newborn | 23 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 4.40 cm | 3.55 cm |
| Medium Leaves | 3.65 cm | 2.50 cm |
| Small Leaves | 3.05 cm | 2.10 cm |
| Newborn Leaves | 1.35 cm | 1.13 cm |

**The average height of the plants is 9.63 cm.**

**Week #5**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 75 % caffeine samples** |
| Large | 36 |
| Medium | 38 |
| Small | 23 |
| Newborn | 27 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 5.30 cm | 4.58 cm |
| Medium Leaves | 4.08 cm | 3.33 cm |
| Small Leaves | 2.93 cm | 2.15 cm |
| Newborn Leaves | 1.57 cm | 1.10 cm |

**The average height of plants is 11.5 cm.**

The temperature and humidity are measured at the beginning of each week:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Weeks of watering with caffeine:** | **Minimum temperature of the Week** | **Maximum temperature of the Week** | **Humidity when the temperature was minimum** | **Humidity when the temperature was maximum** |
| #1 | 1ْC | 51ْC | 53% | 55% |
| #2 | 1ْC | 51ْC | 43% | 43% |
| #3 | 1ْC | 51ْC | 54 % | 56% |
| #4 | 1ْC | 51ْC | 44% | 44% |
| #5 | 1ْC | 51ْC | 73% | 74% |

**“100% Caffeine” Solution**

## **Week #1**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tray with a plant** | **Amount of radish plants in a tray** | **Amount of large leaves** | **Amount of medium leaves** | **Amount of small leaves** |
| #1 | 1  1 | 2  no | no  3 | 2 newborn  1 newborn |
| #2 | 1  1  1 | No  No  No | 2  2  2 | 1; 1 newborn  1  2 |
| #3 | 1  1  1 | No  No  No | 2  2  2 | 2 newborn  2 newborn  2 newborn |
| #4 | 1  1 | No  1 | 2  3 | 2 newborn  no |
| #5 | 1  1 | No  No | 2  2 | no  1 newborn |
| #6 | 1  1 | No  No | No  2 | 2  1 newborn |
| #7 | 1  1 | No  No | 4  4 | No  no |
| #8 | 1  1 | 4  4 | No  No | No  no |
| #9 | 1  1 | No  No | No  No | 2  2 |
| #10 | 1  1  1 | No  No  No | 2  2  2 | 2 newborn  1; 1 newborn  1 newborn |

The table above shows **how** the data is being collected. Further on the tables will be showing only the average results of the collected data, in this way it will be easier to see the difference between the results of the data of every single week.

Totaling all the information above we can see that there is:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 100% caffeine samples** |
| Large | 11 |
| Medium | 40 |
| Small | 11 |
| Newborn | 17 |

The leaves have a green color and the stems have a pale green color. The table below shows the average length and width of the leaves:

|  |  |  |
| --- | --- | --- |
| **Leaves Size** | **Average Length** | **Average Width** |
| Large size | 2.33 cm | 2.15 cm |
| Medium Size | 1.92 cm | 1.48 cm |
| Small Size | 1.26 cm | .94 cm |
| Newborn Leaves | .58 cm | .42 cm |

**The average height of plants is 3.88 cm.**

Everything that we can see in data in the table above tells us that there are leaves that have already reached medium size and therefore 17 newborns were produced.

## **Week #2**

The results are shown below in the table:

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 100 % caffeine samples** |
| Large | 33 |
| Medium | 36 |
| Small | 24 |
| Newborn | 9 |

The acquired data shows that medium size leaves grew up to the large size, and increased the amount of large leaves by that, the small ones grew up to the medium size, producing a small amount of newborns, and the newborns grew up to the small size and therefore the amount of small leaves in a sample increased.

Below you will see the table with average length of the leaves:

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 3.27 cm | 1.62 cm |
| Medium Leaves | 2.26 cm | 1.7 cm |
| Small Leaves | 1.53 cm | 1.23 cm |
| Newborn Leaves | 1.1 cm | .7 cm |

**The average height of plants is 6.43 cm.**

**Week #3**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 100 % caffeine samples** |
| Large | 27 |
| Medium | 45 |
| Small | 57 |
| Newborn | 15 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 4.3 cm | 3.28 cm |
| Medium Leaves | 2.88 cm | 2.6 cm |
| Small Leaves | 2.43 cm | 1.8 cm |
| Newborn Leaves | .9 cm | .5 cm |

**The average height of plants is - 8.1 cm.**

**Week #4**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 100 % caffeine samples** |
| Large | 35 |
| Medium | 33 |
| Small | 25 |
| Newborn | 29 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 5.55 cm | 4.35 cm |
| Medium Leaves | 3.50 cm | 3.08 cm |
| Small Leaves | 2.80 cm | 2.23 cm |
| Newborn Leaves | 1.4 cm | 1.25 cm |

**The average height of plants is 8.78 cm.**

**Week #5**

|  |  |
| --- | --- |
| **Size of the leaves** | **Amount of the leaves in the 100 % caffeine samples** |
| Large | 34 |
| Medium | 57 |
| Small | 29 |
| Newborn | 29 |

|  |  |  |
| --- | --- | --- |
| **Sizes of the Leaves** | **Average Length** | **Average Width** |
| Large Leaves | 5.98 cm | 4.40 cm |
| Medium Leaves | 4.00 cm | 3.13 cm |
| Small Leaves | 3.08 cm | 2.15 cm |
| Newborn Leaves | 1.73 cm | 1.27 cm |

**The average height of plants is 11.78 cm.**

The temperature and humidity are being measured every week:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Weeks of watering with caffeine:** | **Minimum temperature of the Week** | **Maximum temperature of the Week** | **Humidity when the temperature was minimum** | **Humidity when the temperature was maximum** |
| #1 | 1ْC | 51ْC | 53% | 55% |
| #2 | 1ْC | 51ْC | 43% | 43% |
| #3 | 1ْC | 51ْC | 54 % | 56% |
| #4 | 1ْC | 51ْC | 44% | 44% |
| #5 | 1ْC | 51ْC | 73% | 74% |

***Data Journal***

|  |  |
| --- | --- |
| **DATE** | **DESCRIPTION** |
| January 19, 2001 | Radish seeds are planted, 1 seed in a pot. Two different trays with pots are used. 50 pots total. Watered with regular water, because if they will not grow, I would not be able to tell either it is the influence of caffeine or influence of some other factor. While watering, the water is being put directly on the top of the soil of each individual plant. |
| January 21, 2001 | The seeds watered with regular water, none of them had shown up yet. The temperature remains low, around 0ْC. |
| January 23, 2001 | The seeds watered with regular water, none are showing up yet. |
| January 25, 2001 | The seeds watered with regular water. 5 out of 25 in the first tray have showed up, about .8 cm above the surface. 8 out of 25 have showed up in the second tray, around the same height. |
| January 27, 2001 | The seeds watered with regular water, 2 more in a tray #1 have showed up, and 6 more in a tray #2. Now I have 7 out of 25 in tray #1, and 14 out of 25 in a tray #2. Such a significant difference could be explained by the difference in the depth of location of the seeds in tray #1 and tray #2. In the tray #2 pots are not as wide as the ones in tray #1, and that is why after planting them there appeared to be more soil above the seeds in tray #1 than soil above the seeds in the tray #2, and so it is harder for plants to get out of soil and reach the surface. The temperature is still very low. |
| January 29, 2001 | The seeds watered with regular water. Temperature is low. The soil is really cold. At night it is around 0ْC. Plants are growing really slow. The amount of them remains the same. |
| January 31, 2001 | The seeds watered with regular water. Temperature is still cold. 2 more plants in tray #2 showed up. |
| February 2, 2001 | The plants watered with regular water. They are growing slowly. 1 plant in tray #2 died, and 2 plants in tray #1 died. Now I have 5 plants in the tray #1 and 15 in the tray #2. |
| February 4, 2001 | The plants watered with regular water. No more newborns. Growing slowly. |
| February 6, 2001 | The plants watered with regular water. Growing really slow. The temperature remains low. |
| February 8, 2001 | The plants watered with regular water. 2 newborns in the tray #2. The growth rate is really slow. |
| February 10, 2001 | The plants watered with regular water. No newborns. The temperature remains low. |
| February 12, 2001 | The plants watered with regular water. No newborns, but 1 plant in a tray #1 died. So, now I have 4 plants in it, and 17 in a tray #2. |
| February 14, 2001 | The plants watered with regular water. No newborns, the rate of growth is really slow. 1 plant in tray #2 died, and now it is 16 plants in it. I think those deaths can be explained by the low temperature that makes the soil freeze at night. |
| February 16, 2001 | The plants watered with regular water. No newborns. The plants grow really slow. The temperature starts to go up a little bit. |
| February 18, 2001 | The plants watered with regular water. No newborns. Plants have green color, and no taller than 4. 2 sm. |
| February 20, 2001 | The plants watered with regular water. No newborns. |
| February 22, 2001 | The plants watered with regular water. No newborns. Plants have the same green color. |
| February 24, 2001 | The plants watered with regular water. No newborns. The color of plants is green. |
| February 26, 2001 | The plants watered with regular water. No newborns. The temperature is getting higher. |
| February 28, 2001 | The plants watered with regular water. No newborns. The temperature is not as cold any more. |
| March 1, 2001 | The plants of the tray #2 are left for samples, the ones in the tray #1 are of no use any more and they are taken away. The plants watered with regular water. They have green color. |
| March 3, 2001 | The plants watered with regular water. To replace the tray #1 plants I have planted 40 more samples – 40 pots with a various amounts of seeds in it - 2 to 5. In that way if some of them will not grow, the others will grow, so I will not have to replant them again. Also - I have 16 plants in tray #2, the old ones, so I can use them for my experiment as well, for example – to see if their growing rate in a certain caffeine solution will be higher than the one of other plants in a different caffeine solution. In that way I also will have around the same amount of samples for each caffeine solution: tray #2 – 16 plants for one caffeine solution; new tray – around 20 plants that will survive for each caffeine solution. |
| March 4, 2001 | The seeds and plants are watered with regular water. Since the temperature went up, plants will need more water because the evaporation will be higher. Because of that now on I will be watering them every day, and not like before – every other day. The technique of watering them also have changed – I will be putting water on the bottom of the tray, so the amount of water needed by plants will be absorbed through the holes in the bottom of the pots with the roots of the plants. This way they will have as much water as they need. But I will visit them every day and add some more water in the trays, meanwhile making sure that the trays are in a fixed straight position, so the water will be distributed evenly through the bottom of the trays. |
| March 5, 2001 | The seeds and plants are watered with regular water. Seeds have not shown up yet. The plants have a green color, and they are slowly growing up. |
| March 6, 2001 | The seeds and plants are watered with regular water. Seeds have not shown up yet. |
| March 7, 2001 | The seeds and plants are watered with regular water. Seeds have not shown up yet. |
| March 8, 2001 | The seeds started to show up, about .7 cm above the ground. They are all watered with regular water. They all have green color. |
| March 9, 2001 | The plants watered with regular water. They are slowly growing. |
| March 10, 2001 | The plants watered with regular water. |
| March 11, 2001 | The plants watered with regular water. They absorb water really good and none of them have died yet. |
| March 12, 2001 | The plants watered with regular water. They are growing well. They have green color. The stems of the old plants from tray #2 turned dark pink, the leaves stayed green. |
| March 13, 2001 | The plants watered with regular water. |
| March 14, 2001 | The plants watered with regular water. Slowly growing up. |
| March 15, 2001 | The plants watered with regular water. |
| March 16, 2001 | The plants watered with regular water. When I touch the leaves of either one plant - I can feel how strong it is – it seems to be very strong. |
| March 17, 2001 | The plants watered with regular water, they are growing. |
| March 18, 2001 | The plants watered with regular water. |
| March 19, 2001 | The plants watered with regular water and reached the height where it will be safe to start the project – all at once the old plants and the new ones. |
| March 20, 2001 | **BEGINNING OF THE PROJECT** The plants are watered with solutions of different caffeine concentration: 16 old ones with 25% caffeine solution; 10 pots with 50% caffeine solution – 26 plants total; 10 pots with 75% caffeine solution – 26 plants total; 10 pots with 100% caffeine solution - 23 plants total; 10 pots with no caffeine – 38 plants total, so it will be a controlled plants that I can compare to the ones that will grow on a caffeine solution. The initial data have been taken as well – the minimum and maximum temperature for the past week, the humidity of the air when the temperature was minimum or maximum, the amount of plants in each pot, the average length and width of the leaves, and the average tallness of the plants. Also – how many large, medium or small leaves on each plant. All that information you can find in the tables with data under the PROCEDURE section. Method of watering have changed – now it is not the same water for all the plants, so each one pot out of ten that belongs to one caffeine concentration group is being watered separately, putting the right caffeine concentration on the soil directly in the pot. |
| March 21, 2001 | The plants are watered with caffeine solutions, but just a little bit. The reason is that the soil was still really wet, even though the weather stayed the same hot all the time. And it is a strange thing, because all the time before that the plants have been absorbing water really fast. I moved out the non-caffeine plants because the caffeine solutions of other neighboring plants could come out through the holes on the bottom of the pots and be absorbed by the roots of the plants that should be grown without caffeine in it. |
| March 22, 2001 | I could notice that the old plants that are growing in 25% solution of caffeine grew up a centimeter or so, some of them. Their soil still stayed wet, and the soil of other plants stayed wet as well. I decided to water them just a little. The young plants seemed to stay the same height as they were before. |
| March 23, 2001 | Some of the leaves of the plants that I am watering with caffeine turned yellow. The ones with 25% solution had the least amount of yellow leaves though – they had a very few. I watered them just a bit. No significant change in growth can be seen. |
| March 24, 2001 | The plants’ soil is still wet I think the leaves turn yellow because of too much moisture in the soil. That is why I decided not to water them until it dries up. |
| March 25, 2001 | The soil of the 25% caffeine solution plants appeared to be dry – a good explanation for it will be that the pots that it grows in are smaller than the pots of the young plants and the old plants themselves are larger than the young ones, that is why they used up their water faster than it will take for the young ones. The soil of the young ones is wet, so I watered the 25% solution ones and didn’t water the rest of the plants. Other thing about the soil being wet – there was a big rain over the night from the 24 to 25, maybe that is why the soil stayed wet - there was too much moisture in the air. Significant difference in color can be seen between the non - caffeine plants and plants that are watered with caffeine. Even though the soil of the non - caffeine stayed wet as well as the soil of the ones that are being watered with caffeine, the non - caffeine plants remain green color and have no yellow leaves. And the yellow leaves of the plants that are being watered with caffeine feel hard and strong if you touch them. I am already starting to think if caffeine solutions might be influencing photosynthesis in my plants. |
| March 26, 2001 | The soil of plants is still wet, the 25% solution ones are a little bit dry, so I watered them a little bit. There some yellowish color on the non – caffeine plants, but different from the ones that I am watering with caffeine. I think in this case it is the moisture that makes them become a little yellowish. The first half of week #2 data collection. Amount of different sizes of the leaves in each sample sizes is logged in the table. The plants besides the 25% ones are not watered. |
| March 27, 2001 | The soil of the plants is still wet. I did not water them. The second half of the data for week #2 was collected. The plants are slowly growing. |
| March 28, 2001 | Plants are watered. Growing slowly. |
| March 29, 2001 | Plants are watered in the morning. Growing slowly. |
| March 30, 2001 | Visited in the evening. The soil got very dry. Plants were very dry. Watered them. |
| March 31, 2001 | Plants with non caffeine environment were damaged the most, they starting to recover. Watered them again. |
| April 1, 2001 | Significant difference in the height of plants is noticed – the plants watered with 25% caffeine solution grew the tallest; 50% - taller than the 75% ones and the 100% are the shortest. The non-caffeine ones are approximately the same height as the 75% caffeine solution ones. The plants that are being watered with tap water recovering really slow and were damaged significantly in compare with the ones being watered with different caffeine solutions. Maybe caffeine protected them in some way from drying out on the sun. Because all of the plants are receiving relatively the same amounts of water. |
| April 2, 2001 | The soil is wet. I did not water the plants. Third data is collected. Everything measured and recorded, the plants are growing the difference in height of plants between the groups with different caffeine concentrations are not seen as much as before, but if to look closely are still noticeable. |
| April 3, 2001 | The plants are growing, but their height differs from different caffeine concentrations. Plants are not watered because their soil is still wet. |
| April 4, 2001 | The plants are watered. The difference in height is not as noticeable as before. |
| April 5, 2001 | Plants are watered, the ones with caffeine grow much better than the ones without it, and their leaves don’t turn yellow. Same with the ones without caffeine in the soil – leaves are green. |
| April 6, 2001 | Raining all day, a lot of moisture in the air. Plants were not visited. |
| April 7, 2001 | Raining all day. Plants are visited. No significant changes are noticed. The plants are watered. Growing slowly. The 25% ones are going to have flowers soon. |
| April 8, 2001 | Raining all day long. Plants were not visited. |
| April 9, 2001 | Raining all day. Plants are watered. No significant changes are noticed. The plants with caffeine in them seem to have more green color than the ones without caffeine in them. Could be explained by the thing that the ones with plain water in them are still recovering from drying out. |
| April 10, 2001 | Forth data collection. All the data is measured and recorded in tables. Plants are watered. No significant difference in height of plants is noticed. |
| April 11, 2001 | Plants are not watered because the soil is still wet. There is a slight difference in the height of plants – but not like it was before. Earlier I was observing the 50% caffeine solution to be the tallest out of non – caffeine, 75%, and a 100% ones. Now it is opposite – the 100% ones are the tallest out of non-caffeine, 75% and 50%. And their leaves have the largest surface area. |
| April 12, 2001 | Plants are watered. |
| April 13, 2001 | Pictures of plants are taken. Comparing non-caffeine plants with the ones with amounts of caffeine in the soil. The height and conditions vary significantly between different concentrations. The plants are not watered because the soil remained wet. |
| April 14, 2001 | Plants are watered. The difference in height does not disappear. You can see the difference. Indeed, it is getting even more noticeable. |
| April 15, 2001 | Plants are not watered, because the soil stayed wet. Could be caused by a slight drop of temperature for the past week. |
| April 16, 2001 | Plants are watered. The difference between the heights is noticeable. |
| April 17, 2001 | Fifth data collection. All the data was collected and recorded in tables. Analyzed and the results were carefully recorded in tables, and described in the conclusion part of the project. Also – a lot of comments were made during the procedure part. |
| **THE PROJECT IS OVER** | |

***Conclusion***

The project is fortunately completed, and it is now time to draw a final line under everything shown and said above. All the data was collected during the period between the 20th of March and the 17th of April. The results were analyzed and put in graphs. The collected data was:

* length of large, medium, small and newborn leaves of 0%, 25%, 50%, 75% and a 100% caffeine solution mediums
* width of large, medium, small and newborn leaves of 0%, 25%, 50%, 75% and a 100% caffeine solution mediums
* height of the plants that were being watered with - 0%, 25%, 50%, 27% and a 100% caffeine solutions
* weekly high and low temperatures
* weekly humidity of the air when the temperature was minimum or maximum

The average height of the plants, width and length of the leaves was recorded in tables. Average was taken for simplicity – so it will be easier to see how much of a change occurred in plants between different weeks of data collection.

In the ***data journal*** I mentioned that during the first week the leaves of the plants that were being watered with caffeine solutions turned yellow. And I proposed the idea of them influencing the photosynthesis of plants. This statement seemed to be inaccurate. There are several reasons for that – first of all in about four days after it stopped raining the leaves went back to normal green color and never turned yellow again. There could be another explanation to this as well – maybe caffeine does not have a very good influence on plants when they are on the early stage of development. This idea comes from the 50% caffeine solution plants to be taller than the 100% ones at the very beginning, but they became equal about three days after the difference was noticed, and then, as the plants grew older, the 100% caffeine ones appeared to be the strongest and largest out of all the other plants (the 25% ones I don’t count, because they were old by the time the young ones entered the experiment). Furthermore, on the 30th when the weather was really dry, the plants that were being watered with regular water were damaged by drying out a lot, while the other plants with caffeine almost weren’t damaged. I could think that caffeine protects them in some way from a lot of evaporation. But I don’t know for sure, because I haven’t made an experiment on this yet. At the end of the experiment, after the last data collection, I compared all the groups of plants with each other and I have noticed that the ones that I was watering with the regular water were the weakest, the shortest and the smallest ones. On the other hand there were the !00% caffeine solution ones that appeared to be the strongest, the tallest and the largest out of the rest of the plants – 0%, 50% and 75% ones. The 25% ones I am not counting because they were large from the beginning. The results of the comparing you can see below:

Tallness comparison

Large leaves comparison

Medium leaves comparison

#### Small size comparison

Newborns comparison

###### Final Comparison

As you can see, the experiment really did support my hypothesis, and caffeine does influence the metabolism of plants – at least ***radish.*** Now I know that caffeine has a good influence on plants – makes them grow large and strong. The successful amount of caffeine was the 100 % solution. And from this point on I can make other experiments with influence of caffeine on plants – to see if it really does protect them from diseases and insects, or to see how does it change the evaporation in leaves.

***Recommendations***

* the very first one will be is that when making an experiment, the place for an experiment should be easy to get to, but if you are really good at jumping over the fence carrying 4 bottles of coffee in your hands, and doing it under the rain in slippers, then its not going to be a problem (ask for the key from your teacher)
* before making an experiment, always think why did you pick this particular kind of coffee to get the caffeine from
* various concentrations of caffeine solutions are needed for the experiment, and I didn’t get to include the 25% one in it, but it is really important to make sure that the plants are being watered the same way, being kept in the same part of the greenhouse, and being watered regularly (it would be really painful if you would loose them before the experiment is over), and that they all were planted on the same day all together
* for the experiment all the plants with different caffeine concentrations should be put separately, because when you water them ,the excess of caffeine solution comes out of the little holes on the bottom of the pots and mixes in the tray with the rest of the caffeine solutions that come out of the same holes on different pots with different caffeine concentration and is being absorbed by plants that are not suppose to take this mixture, so it is better to put them in separate trays
* coffee has to be fresh any time you want to water your plants, because once before making an experiment I made a lot of coffee and let it stay for a month in a greenhouse (I was waiting to start my project) and I noticed when I opened it that it began to decay – some white parts appeared, and the brown parts were separate from them, so it won’t be a good thing to water them with spoiled coffee, because as soon as will run out of it, you would have to make a new and fresh one, and it will be a changing variable, when it suppose to be unchangeable
* plan you experiment ahead of time, because if you will have a vacation in between – winter or spring break – and you will have to leave with your parents or someone else, and if it will be in the middle of the experiment, it wouldn’t be a very good thing
* fast growing plants are good for this experiment
* don’t water the plants with caffeine solutions when you have just planted them, because if they won’t grow, you will not be able to say if it is caffeine, or weather or something else that won’t let them grow
* the best way to plant the seeds is to fill the pot with soil about ¾ and then put 2-3 seeds in it (to make sure that at least one of them will grow) and put soil on top of it – the remaining ¼ of the pot
* if all of the 2-3 seeds grew up, and you want to leave just one of them, make sure that you leave the ones of the same average height, so they will have the same average height before you start watering them with coffee

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10. 10 Research on <http://coffeefaq.com/caffaq.html#Chemistry> all the cursive words in this paragraph that have information about caffeine contents are from the given web-page [↑](#footnote-ref-9)