EFFECT OF THE NUMBER OF MAGNETS USED FOR MAGNETIC WATER TREATMENT ON THE GROWTH OF LENTILS

(*Lens culinaris)*

By

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ABSTRACT:

Water is one of the most crucial resources for health and agriculture that is becoming more valuable each day. With the rising demand for clean and consumable water, the challenge for managing the water resources continues to grow. Mineral water prevents plants from absorbing nutrients from the soil making it useless in agriculture. Magnetic water treatment is a method that can be used to break down the dissolved particles in the mineral water, making it easier for the plant to absorb water without its roots getting blocked off by the particles. This makes the method useful to perform agriculture in areas where soft water is not accessible. The treatment also decreases the surface tension of the water, allowing more water to be absorbed than usual. This increases the yield of the plant and efficiency of the harvest overall. In this investigation, I conducted the magnetic treatment on mineral water with different numbers of identical neodymium magnets: 0, 2, 4, 6, and 8. The treated water was then given to Lens culinaris seeds and their growth was observed for 10 days. The research question is: **How does the number of magnets used in the treatment of mineral water affect rate of growth, in terms of final length and number of leaves in 10 days, of lentils *(Lens culinaris)*?** The hypothesis is that **the rate of growth of the plants will increase as more magnets are used for the treatment.**

The results showed a significant increase in the final length and number of leaves of the plants, showing that magnetic treatment had a positive effect on the plant growth, as predicted. This implies that soft water can be saved for domestic and health purposes while hard water can be used for agriculture.

Word Count: 291

INTRODUCTION

Being interested in magnets since my early childhood, I decided to base my essay on the concept of magnetism. As I preferred to prepare my essay on Environmental Systems and Societies, I began researching effects of magnets on plants and applications of magnets in agriculture.

Magnets

Magnets are objects that have a magnetic field in which any ferrous objects like iron or nickel are attracted to the magnet. Although magnetic fields naturally occur in magnetic objects, running a current thorough a wire, causing electrical charges to move among it, can also create them. Generically, magnets are used in domestic applications such as televisions, speakers and computer disks. They are also used in the industry by benefiting from their ability to attract heavy metal objects, which are impossible to be moved by hooks or claws. A third well-known field using magnets is medicine. Ancient civilizations like the Egyptians, Romans and the Chinese have all used magnets for medical treatments. [1]

Magnetism in Agriculture

In addition to all the uses of magnets have been proven to be useful in the field of agriculture. [2] The French chemist Louis Pasteur discovered that the magnetic field

. [1] Jezek, Geno "Industrial Uses of Magnets" How Magnets Work!. 2006-2013. Web 17 March 2014. <http://www.howmagnetswork.com/uses.html>

[2] "Magnetism in Agriculture" Mundimex. Mundimex Inc. Web. 15 March 2014. <http://www.mundi.com/agrieng3.html>

of Earth had a stimulating effect on the fermentation process in 1862. Decades later, in 1950, Dr. Albert Roy Davies used magnetism to trigger plant growth, inspiring his apprentice Peter Kulish to invent the magnetizer. In 1996, the Florida State University's signature Magnet Lab conducted an experiment by exposing various plant seeds to strong magnetic fields caused by 1.5 Tesla magnets. [3] The results of the experiments showed that plants exposed to magnetic fields had earlier germination and faster growth rate than those weren't. For example a bean seed would normally germinate and grow pods in 70 to 80 days but when exposed to the magnets, the time would shorten up to 45 days.

There was not a complete conclusion on how the magnets achieved such a change on the plants but it is predicted that the magnets altered the membrane structure of the plant cells so that the plants absorbs more water and nutrients. Such a use of magnets would create a wide variety of opportunities in the future. The research team expected that magnets could be used agriculture and also Ching Jen Chen, the director of the research, suggested that magnets could be used to grow plants in space since they both increase the growth rate and simulate microgravity to direct the plats orientation of growth. This way it would be possible to feed an entire space crew without having to stockpile food beforehand.

In modern agriculture, Kulish's invention magnetizer is used to decrease the surface tension of water. Therefore the water is easily absorbed into the soil and gets more soluble. Magnetizer treated water allows the cilia on the root to more easily absorb water and minerals from the soil. Also the water passes on electromotive

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[3] Chen, Ching Jen "Magnetic Effect on Plants" YouTube. 30 July 2013. Florida State University Communications Group. < http://www.youtube.com/watch?v=k1y8X4XoP4c> Web. 15 March 2014.

forces to the plant. Thanks to these forces, the plant is provided with both faster and healthier plant growth. The plant's cilia grow further into the soil and receive more minerals. The result of Magnetizer used on water used in agriculture is a yield of healthier and faster growing plants.

Once electromagnets are fitted to a stainless steel pipe that is connected to the water source, any water particle that passes through the pipe is influenced by the magnetic field created by the magnets. The particles then vibrate causing both a decrease in the surface tension but also the breakdown of salt particles in the water that makes it impossible to use it in watering the plant.

This makes the system even more preferable as it can be used to promote agriculture in regions where water availability is limited and the farmers have no choice but to use salty water. USAID (the lead American agency that assists poor countries) has launched a project in which they aim to apply the technology to the Jordan Valley, allowing the farmers to increase their uses of over 3500 hectares of watered farmland. It is expected that the project will benefit over 10000 farmers in the region along with their families. The project will boost the quality and quantity of the products. The experimental stages of the project have showed that farmers using treated water produced 20 percent more than the ones who didn't. [4]

Mineral water and plant growth

Mineral water distributed in bottles hosts a solution of up to 3,000-ppm solids. When plants are watered with such water, the minerals that were previously dissolved

[4] Malki, Rana "Magnets Help Plants Grow" USAID. 25 February 2014. USAID. Web. 15 March 2014. <http://www.usaid.gov/news- information/frontlines/feed-future/magnets-help-plants-grow>

in the water will start to accumulate in the soil. As the water absorbs water from the soil, the semi permeable membrane leaves out the minerals on the roots. When too much minerals and salts gather around the roots of the plants the plant is put under stress by the blockage of water. The built up minerals are also toxic to the plant.[5]

Since, magnetic water treatment is simple enough to be handled domestically, the concept is suitable to be applied in any field of both professional and domestic architecture. Farmers can operate their farms with higher efficiency without using any chemicals that would harm the environment. According to the concept, healthier crops that grow faster can be achieved by using magnetic water treatment on the water given to the crops. A broad application of the concept would result in more eco friendly farms that give sooner yield. The fact that the system breaks down salt particles in the water makes it an even more appealing concept. Even farms without access to non salty water can benefit from magnetic water.

This essay is based on an experiment conducted to investigate the effects of number of magnets used in the water treatment system on plant growth. The research question is "How does the number of magnets used in water treatment affect rate of growth of lentils *(Lens culinaris)*?" Five groups of lentils are planted in the same conditions, in terms of temperature, pressure and light intensity. Each group has five instances of the lentils of the same shape, size and type, planted at the same depth in identical plastic cups filled with the same type of soil. The water treatment is conducted in cast iron cooking vessels. Each group of lentils has its own vessel, fitted

[5]LeBoeuf-Little, Nicole J. "The Effects of Mineral Water on Plants." *GardenGuides*. Demand Media, Mar.-Apr. 2010. < http://www.gardenguides.com/101273-effects-mineral-water-plants.html> Web. 04 Dec. 2014.

with an increasing number of identical magnets. The first group has none, the second has 2, the third group has 4, the fourth group has 6 and the fifth group has 8 magnets attached to its corresponding vessel. The magnets used in this experiment are neodymium magnets in the dimensions 30x10x5mm. The magnets are arranged in two equal rows at opposite sides of the vessel and opposite poles of the magnets in each row are facing towards the center. Once the lentils and vessels are set up, 50 ml of mineral water is filled in each of the vessels After waiting for an hour, 10ml of the water from its corresponding vessel is given to each lentil using a needle-les injector. This process is repeated everyday at 18:00 for 10 days. At the end of 10 days, the lengths of the plants were measured.

RESEARCH QUESTION

How does the number of magnets used in the treatment of mineral water affect rate of growth, in terms of final length and number of leaves in 10 days, of lentils *(Lens culinaris)*?

The question will be answered through the experimental data that is gathered through observation of the growth of the lentils for the course of 10 days.

HYPOTHESIS

The magnets are known to decrease the negative effects of minerals in the water on the plant so more magnets would mean less interference on plant growth. Therefore the hypothesis would be "**The plants given water that is treated with more magnets will grow higher.**"

METHOD DEVELOPMENT AND PLANNING

The experiment aims to observe the growth of *L. culinaris* watered by water that was exposed to magnetic treatment by different numbers of magnets. To observe the effect more vividly, it should be a controlled experiment. All of the factors except the number of magnets should be kept constant. The plants will be given water that will have been exposed to magnetic treatment before the plants are watered. It is also important to maintain a constant watering time to reduce unexpected variables that affect the results. Therefore the treatment and watering times should be properly scheduled. The system prepared for treatment should be composed of a metallic container that will hold the water and provide a surface that magnets can hold on to. The magnets, which are the key factor to the experiment, should be of considerable strength to make the results more clear. Neodymium magnets are preferable for the experiment for their remarkable strength and easy accessibility. The experiment involves 25 seeds, which will be planted in their own container. Which means the planted seeds will occupy an overwhelming area. Such a large are will mean that there will be large difference between the seeds. Separation of seeds would mean that the amount of light received by the seeds would vary, as all seeds will receive the light from an angle that is vividly different from that of the other seeds. To reduce that effect to the minimum, the seeds should be planted in small containers such as plastic

cups. This way, the setup for the experiment will be more compact and undesired effects won't alter the results. Magnets are used to treat hard water, therefore the water used in this experiment should be rich of minerals. Since a large quantity of water is required for the experiment, availability is important as well as a reasonable amount of minerals that would be easy for the magnets to treat. Therefore the most preferable option is sparkling water, which can be found in most markets and does not contain too much minerals. Watering the plants needs to be controlled as well. To check the amount of water given to the plants, an injector should be used. Measuring the growth is also a very significant aspect of the experiment. To receive more solid results the growth will be measured in terms of both size and number of leaves.

Independent	Number of magnets used for treatment (0,2,4,6,8)	-
Dependent	Length of the plant after 10 days	-

Type of variable		Kept constant by
Constant	Type of seeds	Using the same texture size and shape of *Lens culinaris* seeds
	Size of seeds	
	Shape of seeds	
	Texture of seeds	
	Composition of water	Using mineral water for all specimens

	Amount of water	Giving each specimen 30ml water each day
	Time of watering	Watering each specimen at 23:00 every day
	Duration of magnetic treatment	Treating every plant for 1 hour each day
Constant	Temperature	Using the same room for all specimens in the experiment
	Pressure	
	Amount, angle and intensity of light received by the plants	Placing all of the specimens at the same window
	Composition of soil	Using 0.25 L of garden soil for all specimens
	Amount of soil	
	Size of cups	Using identical 0.25L plastic cup for every specimen
	Material of cups	

Constant	Type of magnets	Using 30x10x5mm neodymium magnets for every specimen
	Size of magnets	
	Arrangement of the magnets	Placing half of the magnets on one side of the vessel and half on the other side for every specimen
	Size of the cooking vessel	Using identical cast iron vessels for every specimen
	Material of the cooking vessel	
	Amount of water treated in the vessel	Leaving 30 ml per plant mineral water for treatment every day
	Size of the injector used for watering	Using the same injector for every specimen
	Duration of measurement	Keeping and 10 day experimentation period for every specimen

Table 1: Types and conservation methods of variables

Materials:

- Plastic cup x25
- *Lens Culinaris* seed x25
- 30x10x5 mm neodymium magnet x20
- Cast iron cooking vessel x5
- Garden soil x6.25L
- Mineral water x7.5L
- Needle-less injector
- Ruler
- Alarm clock

Methods:

Preparation of cups

25 identical 0.25L plastic cups and 6.25L of garden soil is needed for the experiment. Since the composition of the soil is a controlled variable the type of soil is irrelevant with the results of the experiment. However it is important to make sure the soil is homogeneously mixed so that every cup receives the same ingredients as the others. Lentils are known to be tolerant to all types of soil unless it is flooded with water.[7] The soil needs to be mixed thoroughly before starting the experiment. The mixed soil is then divided into groups of 0.25L, ready to be used for lentils. All 25 plastic cups are filled with 0.25L of soil. For constant accessibility to sunlight, the cups need to be placed in front of the same window. This will also ensure that all plants are kept in the same temperature and pressure as they are in the same room. The formation of the cups should be in groups of 5 as shown in the figure.

[7] Olpinger, E.S., L.L. Hardman, A.R. Kaminski, K.A. Kelling, and J.D. Doll. "Alternative Field Crops Manual." New Crop Resource Online Program. Purdue University, 13 Jan 2015. <http://www.hort.purdue.edu/newcorp/afcm/> Web. 13 Jan. 2015.

Figure 1: Configuration of the plants

Preparation of water treatment

The water treatment is an important part of the methodology as it sets the independent variable of the experiment. 5 cast-iron cooking vessels and 20 neodymium magnets are needed for this section. For the first vessel, which corresponds to the control group of the experiment, no magnets are used.
For all of the other vessels that have magnets the formation of the magnets are very important. The magnets are stuck on the outer sides of the vessel. While half of the magnets are stuck on one side, the other half is stuck on the opposite side. The polarity of the magnets should also be considered. The same poles of all magnets on one side of the vessel need to be facing the same direction while the same pole of the magnets on the opposite side should be facing that direction. For example if the north pole of the magnets on the right side of the vessel are facing towards right, the north pole of the magnets on the left side should also face right. This makes sure that opposite poles face each other and forms a magnetic field in the vessel. Considering these, the second vessel is fitted with 2 magnets. The third vessel is fitted with 4 magnets. The fourth vessel is fitted with 6 magnets and the last vessel is fitted with 8 magnets. After all vessels are ready, they are placed in the same room with the cups.

Planting the seeds

25 *L. culinaris* seeds are used for the experiment. To prevent alteration on the results, the seeds need to be in the same size, texture and shape. One seed is planted in each cup. The seeds need to be planted in the same depth, 5 mm below the surface.

Watering the plants

Timing is important while attending the plants. The duration of the treatment and the time of watering the plants needs to be constant. An alarm clock is used to specify the exact time for both actions. Mineral water is used in the experiment. 150 ml of the water is left in each vessel at 22:00, 1 hour prior to watering the plants. At 23:00 the mineral water that was left for treatment for 1 hour is used to water the plants. Using an injector, each plant is given 20 ml mineral water from its corresponding vessel. After all plants are watered, their lengths are measured and recorded. This process is repeated for 10 days.

DATA COLLECTION

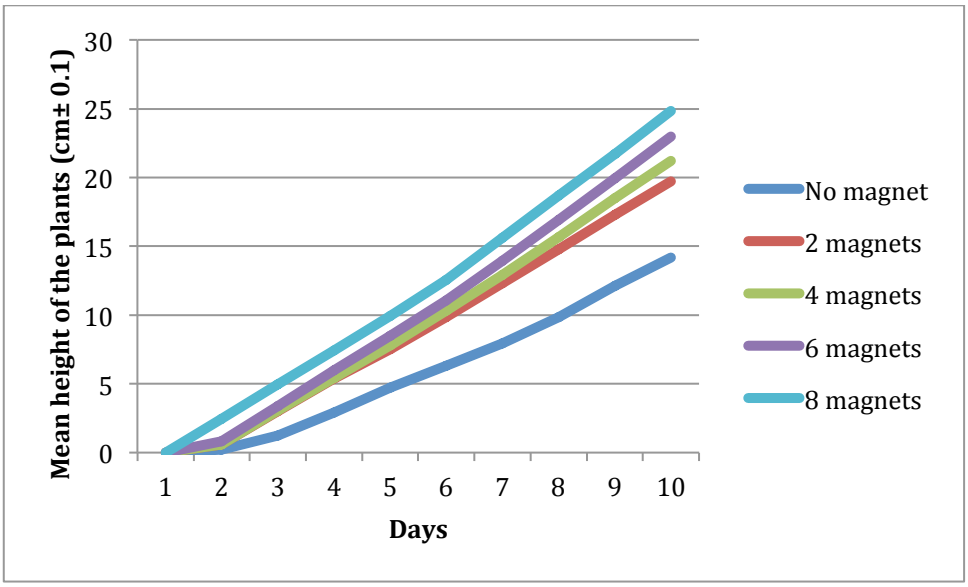
		Trials				
Number of magnets		1	2	3	4	5
	Day	Length of the plant (±0.01cm)				
0	1	0	0	0	0	0
	2	0	0	0	0,6	0,4
	3	0	0,3	1,2	1,9	2,9
	4	0	1,7	3,5	3,9	5,5
	5	0	3,6	6,2	5,9	8
	6	0	4,1	8,6	8,4	10,4
	7	0	4,6	11,4	10,9	12,8
	8	0,3	6,6	13,7	13,4	15,3
	9	1,5	8,6	16,3	16,4	17,9
	10	2,3	11,1	18,7	19,4	19,4
2	1	0	0	0	0	0
	2	1,3	0,7	0,5	0,5	0
	3	3,4	3,2	3	3	2,5
	4	5,9	5,7	5	5,4	5
	5	7,2	8,2	7	7,9	7,4
	6	8,5	10,7	9,5	10,6	10
	7	10,5	13,2	12	13,3	12,6
	8	12,5	15,7	14,5	16,2	15
	9	14,5	18,2	17,9	18,5	17,5
	10	17	20,7	20,5	20,5	20
4	1	0	0	0	0	0
	2	0,1	0,5	1,1	0,9	0,4
	3	2,6	3	3,6	3,4	2,7

	4	5,1	5	6,2	5,9	5
	5	7,6	7,5	8,6	8,4	6,9
	6	10,2	10	11	10,9	9,4
	7	13,3	12,5	13,6	13,4	11,9
	8	16	15,6	16,3	15,9	14,5
	9	19,2	18,9	18,7	18,4	17,3
	10	22,1	21,5	21,1	20,9	20,4
6	1	0	0	0	0	0
	2	0,7	0,5	1,4	0,7	0,8
	3	3,2	3	3,9	3,6	3,3
	4	5,7	5,5	6,4	6,6	5,8
	5	8,2	8	8,9	9,1	8,3
	6	10,7	10,5	11,4	11,6	11,2
	7	13,2	13	14,4	14,6	14,5
	8	16,6	15,5	17,8	17,6	17,1
	9	20,1	18	21	20	20,7
	10	23,5	20,5	24,5	23	23,3
8	1	0	0	0	0	0
	2	3	2,6	2,8	3	0,8
	3	5,5	5,1	5,3	5,5	3,3
	4	8	7,6	7,8	8	5,8
	5	10,5	10,1	10,3	10,5	8,3
	6	13	12,6	12,9	13	11,3
	7	16,2	15,6	16,1	16	14,3
	8	19,3	18,6	18,7	19	17,8
	9	22	21,6	21,6	22	21,3
	10	25	24,6	24,8	25	24,8

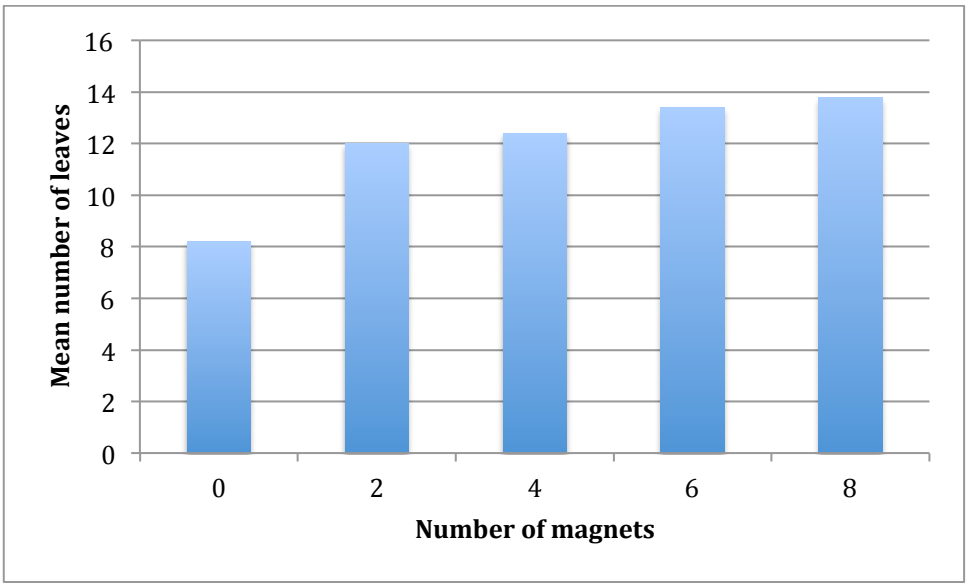
Table 2: Raw data, Length of the plant at different days, trials and number of magnets

		Trial				
Number of magnets		1	2	3	4	5
		Number of leaves				
	0	8	1	9	11	12
	2	10	13	12	13	12
	4	11	12	12	14	13
	6	12	13	13	15	14
	8	14	14	13	13	15

Table 3: Raw data, Number of leaves at the end of the experiment at different trials and number of magnets



Graph 1: Mean height of the plants treated with different number of magnets vs. days



Graph 2: Mean number of leaves vs. number of magnets used for treatment

DATA ANALYSIS

Observing graphs 1 and 2 show that there are two separate clusters of data for the mean values for heights and numbers of leaves. The plants that received magnetically treated water are stacked higher on the Y axis than the plants that didn't. (Graph 1) When the group of magnetically treated plants is observed, it can be seen that the plants grew higher as the number of magnets increased. Similarly, when Graph 2 is observed, among the group of plants that received treatment, being already vividly greater than the plants that didn't receive treatment, the number of leaves keep increasing as more magnets are used.

number of magnet	mean	standard deviation
0	14,18	6,72
2	19,74	1,39
4	21,2	0,57
6	22,96	1,33
8	24,84	0,15

Table 4: Mean and Standard deviation values for final lengths of plants with different numbers of magnets

Number of magnets	mean	standart deviation
0	8,2	4,32
2	12	1,22
4	12,4	1,14
6	13,4	1,14
8	13,8	0,84

Table 5: Mean and Standard deviation values for numbers of leaves with different numbers of magnets

ANALYSYS OF VARIANCE (ANOVA)

Analysis of Variance (One-Way)						
Summary						
Groups	*Sample size*	*Sum*	*Mean*	*Variance*		
0	5	70,9	14,18	56,387		
2	5	98,7	19,74	2,413		
4	5	106,	21,2	0,41		
6	5	114,8	22,96	2,208		
8	5	124,2	24,84	0,028		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*p-level*	*F crit*
Between Groups	329,3096	4	82,3274	6,69917	0,00137	3,73125
Within Groups	245,784	20	12,2892			
Total	575,0936	24				

Table 6: ANOVA test results

To determine the significance of the effects of the independent variable on the controlled variables, the ANOVA test was applied on the data. According to the test, any p-level variation that is above 0.005 renders the effects insignificant. The final length of each specimen of different trial and number of magnets was taken through the test and the resulting p-level variance was 0.00137. Therefore it has been confirmed that the number of magnets used for the water treatment has considerable effects on the growth of *L. culinaris.*

CONCLUSION AND EVALUATION

The research question was :

How does the number of magnets used in the treatment of mineral water affect rate of growth, in terms of final length and number of leaves in 10 days, of lentils *(Lens culinaris)*?

The hypothesis stated that the growth of the plants would be positively affected by the water treatment. It is proven to be true by the data. The growth of plants was affected positively by the use of magnetic water treatment. The effects became more visible as the number of magnets grew. The plants that were given water that was exposed to 8 magnets reached a mean height of 24.82 cm, with the mean number of leaves 13,8. The plants that received no treatment reached a mean height of 14,18 and a mean number of leaves of 8,2. As more magnets were added, the mineral water was exposed to greater magnitudes of magnetic field. The stronger the magnetic field got, the more it helped the plant absorb the mineral water which would be harder to absorb in normal conditions. The results of the treatment reflect on both the heights and numbers of leaves of the plants. There is also a visible gap between the plants that received treatment and the ones that didn't in the graphs of both height and leaves. The significance of the results are confirmed by a 0.00137 variance value from the ANOVA test. Which can be inferred that even the addition of a slight number of magnets, meaning just by adding magnets, the effects can be significantly visible.

To conduct the experiment, five groups of lens culinaris were planted in in soils in individual plastic cups. Each group was watered with mineral water that received magnetic treatment from different numbers of neodymium magnets. For 10 days, the growth of the plants was observed and their heights were measured each day and at the end of the experiment, the numbers of leaves were recorded.

No experiment is without error, so is this one. The procedure allows the influence of both random and systematic errors. First of all, undeniably most of the measurements contain error since they were all made manually using traditional and non-sensitive equipment such as rulers and injectors. The standard deviation values, especially for the plants with fewer amounts of magnets are considerably higher (Table 4) which is a sign of random errors. These random errors include false measurement of the plants height, inaccurate amounts of water given to plants and usage of too much or too less soil. There are also random errors related to time, as it is impossible to start the treatment exactly at 22:00 and distribute the water to the plants at 23:00. These kinds of errors were dealt by doing multiple trials.

There are also systematic errors involved in the methods. Even though the treatment was held at late hours to prevent the high temperatures of daytime from evaporating the water, there is inevitably some evaporation. The water was kept in the vessels until all plants were watered which means the water that is given to the plants the last was kept in treatment for longer than the others.

Another thing that might have altered the interpretation of the results is the plant from the “no-magnet group” that didn’t grow at all. Compared to the other plants in the group, it is obviously a random error caused by uncontrollable variables. It appears to have caused the gap between the plants that received treatment and the

ones that didn't by causing a decline in the mean value of its group. Though this caused the "no-magnet" group to have a lower mean value, it doesn't mean there is no correlation between the number of magnets used for the water treatment and the growth of the plants.

Real life implications of this concept would be that magnets are effective in water treatment even in non-industrial quantities. This means that magnetic treatment can be held in domestic environments by simply using neodymium magnets. It is also a useful opportunity for non-industrialized farmers, as the method has no complexity of execution. The treatment can also be applied for any other use of water when only hard water is available.

To conclude, my investigation explored a new way to make use of mineral water that was originally inapplicable in agriculture. The water resources are exploited by today's population and soft drinkable water becomes harder to obtain every minute. Thanks to water treatment, mineral rich hard water can be used for agriculture for more efficient and sustainable crop yield while soft water can be spared for health applications and domestic consumption.

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