The effects of magnetic fields on plant growth and health

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ABSTRACT

A study was conducted to test the hypothesis that a magnetic field can affect plant growth and health. The study divided plants into three groups. The first group of plant seeds grew in a low magnetic field. The second group grew in a high magnetic field. The third group grew in the absence of a magnetic field, serving as a control group. Several growth parameters were measured, including the germination rate, plant height, and leaf size. In addition, the health status was measured by leaf color, spots, the stem curvature, and the death rate. Plant growth was observed continuously for four weeks. The results showed that magnetism had a significant positive effect on plant growth. Plant seeds under the influence of the magnetic field had a higher germination rate, and these plants grew taller, larger, and healthier than those in the control group. No adverse effects of magnetism on plant growth were noticed. However, the removal of the magnetic field weakened the plant stem, suggesting the role of magnetism in supplying plants with energy.

Introduction

De Souza *et al*. showed that the growth and yield of lettuce could be improved by treatment of its seeds before they were grown, using rectified sinusoidal non-uniform electromagnetic fields.[1] It was observed that magnetism has effects on lettuce at the nursery, vegetative, and maturity stages, including a significant increase in root length and shoot height, a greater growth rate, and a significant increase in plant height, leaf area, and fresh mass. Positive biological effects of magnetism on sunflower and wheat seedlings weights were reported.[2] Further data show that the magnetic field induced by the voltage of a specific waveform enhanced or inhibited mung bean growth, depending on the frequencies,[3] which suggests that the magnetic field on plant growth may be sensitive to the waveform and frequency of the source electrical voltage. The effect of static magnetic field on plant growth has also been studied. Cakmak *et al*. found that static magnetic field accelerated germination and early growth of wheat and bean seeds.[4] Vashisth *et al*. obtained similar results with chickpeas; furthermore, they found that the responses of the plant to static magnetic field varied with field strength and duration of exposure with no particular trend.[5] However, as indicated by a literature review, weak magnetic field exhibited negative effects on plant growth, such as inhibition of primary root growth, in some cases.[6] For instance, exposure to magnetic field inhibited early growth of radish seedlings with decrease in the weight and leaf area.[7] An interesting result is that the biological effect of a magnetic field is different between the south and north poles, as illustrated by a study, which showed that radish seedlings had a significant tropic response to the south pole of the magnet, but insignificant response to the north pole.[7] It is theorized that the south pole of the magnet enhances plant and bacterial growth by conferring energy, whereas the north pole retards their growth. Thus, it is possible to utilize the magnetic north pole against infections or tumor growths. Morphological anomalies in pollen tubes of a particular plant exposed to magnetism were observed,[8] which raises an important question of whether magnetism can cause gene mutation and cancer. This issue is still controversial and demands more research evidence before any conclusion can be drawn.

Experimental Design and Methods

Hypothesis

The main hypothesis is that static magnetic field has effects on plant growth. If plants grow in an environment with magnetic field, they will grow differently than if they grow without magnetic field.

Purposes

The experimental objectives include:

- To observe plant growth based on a set of growth and health parameters under the magnetic field.
- To compare plant growth under magnetic fields of different strengths.
- To compare plant growth under the magnetic field at different points in time.
- To determine whether the magnetic field can influence plant growth based on the observational data.
- To identify the parameters of plant growth affected by the magnetic field, if any.
- To observe changes in plant growth after the magnetic field is removed.

Materials

- Plant seeds – a bag
- Soil – a bag (28 L)
- Sunlight – eight hours per day
- Water
- Magnets – two magnets with the magnetic strength of 0.33 Tesla and 0.49 Tesla, respectively
- Rulers – one
- Magnifiers – one

Procedures

1. Prepare three round plastic or glass containers, each with a diameter of 10 inches and a height of about 6 inches.
2. Place the same soil (mixed natural and artificial) in each container to form the soil bed of about four inch deep.
3. Plant seeds (radish) on the superficial layer of the soil (one inch deep) in each container. Sixteen seeds are planted, so that they are evenly distributed along a circle with a diameter of six inches.
   3.1. In the second container, a horseshoe-shaped magnet of 0.33 Tesla is placed at the center of the circle surrounded by the seeds [Figure 1].
   3.2. In the third container, a horseshoe-shaped magnet of 0.49 Tesla is placed at the center of the circle surrounded by the seeds [Figure 1].
4. Each nursing container is placed by the window facing the east and exposed to the sunlight in the daytime. The plants grow under the room temperature at 25°C with a humidity level ranging between 30 and 50%. The soil in each container is kept wet by watering once every day so that the soil surface is neither dry nor soggy to the touch. The soil moisture was estimated at 0.25 ml/in^2.
5. Record on a weekly basis the number of seeds that have germinated, plant growth, and observations about plant health such as color of leaves, and spots or holes due to pests and diseases. Diseased spots will be quantified. Plant growth will be measured by plant height and leave size as shown in Figure 2.
6. The experimental observation will last for four weeks. The magnets in the third pot will be removed at the end of the third week, but the observation will continue for the fourth week in an attempt to evaluate the reversibility of the magnetic effect on plant growth, if any.

Results

There were three experimental conditions, as shown in Figure 3: (1) no magnet, (2) low magnetic field, and (3) high magnet field. The plants that had no magnetic field surrounding them were found to have slower growth as well as smaller leaf sizes. The growth and leaf sizes increased as the strength of magnetism increased.

The germination rate of the plants without the magnetic field was less than the germination rate of those with a magnetic field as seen in Table 1. In the control group, 12/16 plants germinated during the first week, while 16/16 of the plants growing under

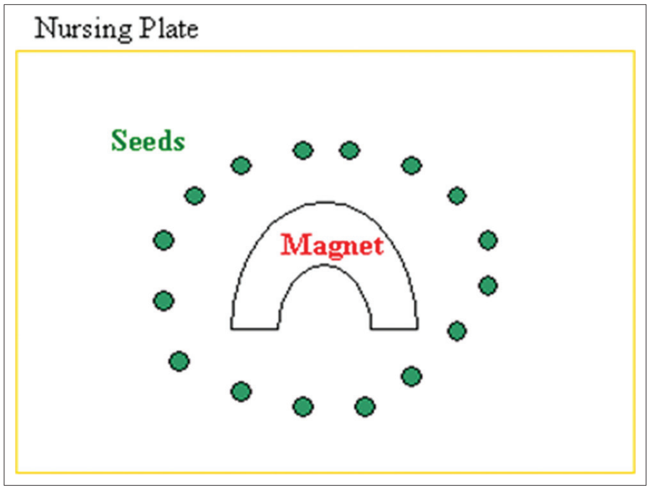

Figure 1: The experiment design where the magnet was surrounded by 16 plant seeds

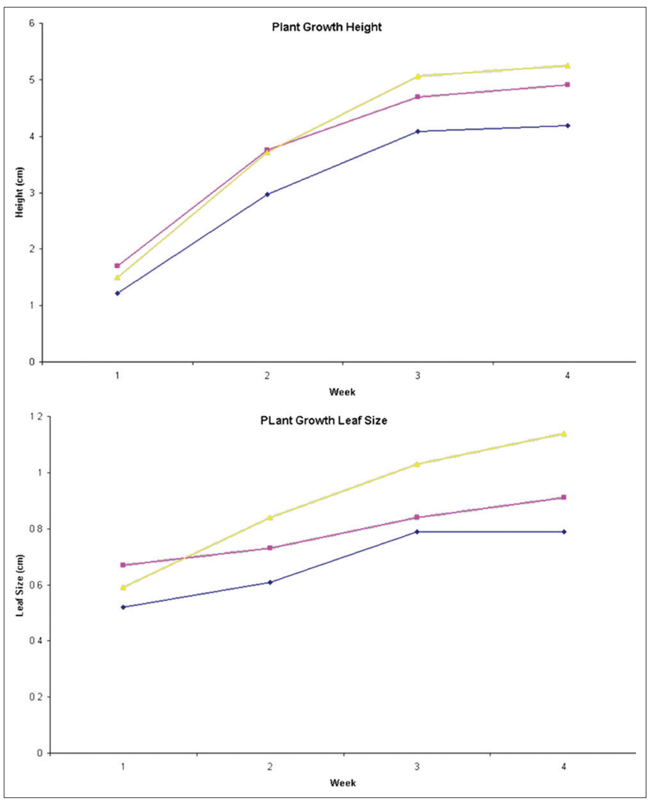

Figure 2: Plant growth is measured by the stem height (top) and leaf size (bottom) every week over a one month period. Blue: Control. Pink: Low magnetic field. Yellow: High magnetic field. The curves suggest that there is consistent positive effect of magnetic field on plant growth

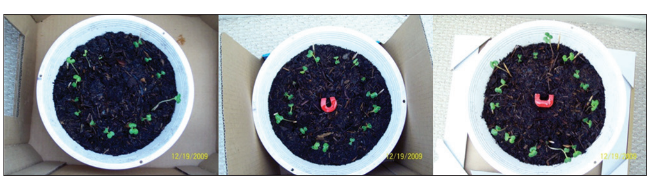

Figure 3: The plant growth in three trial groups with no, low, and high magnetic fields, respectively, in the middle of the experiments (the third week)

Table 1: The unhealthy changes and death of plants in control and experimental groups at the end of the fourth week. In the group with high magnetic field, the magnet was removed at the end of the third week; there was a significant increase in the number of stem changes after the magnet was removed. The control group has a significantly lower germination rate in the first week than the experimental groups with magnetic fields

	Control	Low magnetic	High magnetic
Germination rate	12/16 (1^{st} week) 14/16 (overall)	16/16 (1^{st} week)	16/16 (1^{st} week)
Leaf unhealthy	2/14	2/16	2/16
Stem unhealthy	1/14	1/16	6/16 (4^{th} week) 1/16 (3^{rd} week)
Plant death	2/14	0/16	0/16

Table 2: The average plant height and leaf size in the control group and two experimental groups with low and high magnetic fields, respectively

Results	Plant height (cm)			Leaf size (cm)		
	Control	Low mag	High mag	Control	Low mag	High mag
Week 1	1.22	1.7	1.5	0.52	0.67	0.59
Week 2	2.97	3.75	3.72	0.61	0.73	0.84
Week 3	4.09	4.69	5.06	0.79	0.84	1.03
Week 4	4.18	4.91	5.25	0.79	0.91	1.14

a magnetic field (for both low and high magnetism) did so in the first week. Overall, the germination rate of the control group was 14/16 in the whole study period. The significantly higher germination rate in the first week for the experimental groups with magnetic fields means that magnetism can increase the speed of plant development.

As seen from Table 2, the plants in the groups with magnetic fields grew taller (measured by stem height) and bigger (measured by leaf size) by as much as 25%. For instance, the stem height was 4.18 cm in the control versus 5.25 cm in the high magnetic group at the fourth week. Furthermore, the high magnetic field had more stimulatory effect on plant growth than low magnetic field. The photographs [Figure 3] also show that plants grew with a better overall appearance in the environment with magnetic fields.

As seen from Table 1, the amount of unhealthy stems in the control was 1/14. In comparison, 1/16 of the plants in the trial with low magnetic field had an unhealthy stem, and 1/16 of the plants in the trial with high magnetic field had an unhealthy stem during the third week. When the magnet was removed for the fourth week in the trial with high magnetic field, the number of unhealthy stems increased to 6/16. The number of plant deaths for the control group was 2/14, and the number of deaths for both low magnetic field and high magnetic field groups was 0/16. Thus, more plants died without than with magnetism. Plant stems became unhealthier after removing the magnet in the trial with high magnetic field.

Statistical analysis, shown in Tables 3 and 4, based on *t*-test among groups showed that plants exposed to magnetism (low or high) outgrew plants in the control group in terms of both plant height and leaf size, and these results were statistically significant.

Discussion

Previous research showed that plant growth can be increased by both dynamic[1] and static[4,5] magnetic fields. Magnetism also accelerates germination.[4] These findings were confirmed by my research presented here. However, some studies reported negative results. The difference in research outcomes may be due to variations in experimental design. Taken together, the current evidence seems in favor of the view that magnetism has a positive influence on plant growth and development.

However, previous research studies do not measure the plant health status with and without magnetic influence. My research suggests that magnetism makes plants grow not only faster and bigger, but also survive better. An interesting observation is that a large portion of plant stems became curved after the magnet was removed in the group exposed to high magnetic field. A possible explanation is that magnetism accelerates plant growth and supplies energy. In the absence of magnetism, plants lose energy derived from the magnetic field and the plant stem cannot support its weight.

The differential effect on plant growth between the north and south poles has been noticed previously. One theory is that the south pole causes plants to grow faster, but promotes bacteria, and the north pole of the magnet caused slower growth, but healthier plants. A number of unhealthy leaves were noted in my experiment, but the plants close to the north pole and those close to the south pole do not show any observable difference in their growth and health status. This is perhaps due to the use of horseshoe magnets rather than bar magnets in the experiment.

Conclusions

I have found that the plants surrounded with a magnetic field tend to grow faster, taller, bigger, and healthier, as measured by the plant height, leaf size,

Table 3: Statistical comparison on plant height using paired *t*-test provided by an online statistical calculator:[9]

Comparison	*t*-value	*P* value	Statistical significance
Control versus low magnetism	9.59	0.0024 (< 0.01)	Yes
Control versus high magnetism	4.37	0.022 (< 0.05)	Yes
Low versus high magnetism	0.86	0.45	No

Table 4: Statistical comparison on leaf size using paired *t*-test provided by an online statistical calculator:[9]

Comparison	*t*-value	*P* value	Statistical significance
Control versus low magnetism	5.19	0.014 (< 0.05)	Yes
Control versus high magnetism	3.86	0.031 (< 0.05)	Yes
Low versus high magnetism	1.63	0.20	No

and selected parameters related to their health status. The germination rate in the first week is significantly higher with than without magnetic field. The magnetic field may also supply energy, as reflected by my observation that removal of magnetism causes the plant stem to bend. The results confirm my hypothesis that magnetism affects plant growth and health. In the literature, most similar studies have found the positive effect of magnetism on plant growth, but few have reported the magnetic effect on plant health. Moreover, a new finding in my experiment, which has not been reported in the literature, is the potential relationship between magnetism and plant energy. It means that magnetism affects both the structure and function of a plant. Finally, it was not suggested by my study that the magnetic field caused any negative biological effect, as far as the plant growth and development is concerned.

Acknowledgement

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About the Author

Edward Fu is 15 years old and doing Biology and Chemistry at University High School in California. He is on the Science Olympiad Team at his school and won a medal in 8th and 10th grades.

Acknowledgment

Lorna Quandt is a graduate student in Psychology at Temple University in Philadelphia, USA. She uses EEG (electroencephalography – the recording of electrical activity in the brain using electrodes placed on the scalp[1]) to study her areas of interest: action processing, social cognition, and the overlaps between action execution and action observation.[2]

Lorna is a member of the International Advisory Board of the Young Scientists Journal, assisting our group of school-student editors with the science in the most challenging articles submitted to the journal. She is now stepping down from the IAB to focus on her work, and everyone on the YSJ team would like to thank Lorna for the guidance and time she has given us, particularly whilst preparing Issue 10.

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