EFFECTIVENESS OF UTILIZING INDUCED MAGNETISM ON THE SEED GERMINATION OF RADISH (*Raphanus sativus*)

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Abstract
This study investigated the effectiveness of utilizing induced magnetism on the seed germination of radish (*Raphanus sativus*) in terms of growth rate, growth speed, shoot growth, and overall development. This study utilized two groups that consisted of an experimental group where induced magnetism was present one control group where there was an absence of induced magnetism in the seed germination of Radish (Raphanus sativus). Moreover, this study aimed to determine the significant difference between the two in terms growth rate, growth speed, shoot growth, and overall development. Both groups had the same amount of radish (Raphanus sativus) seeds planted in a rectangular wooden container with the same amount of measurement and soil content. This study used an experimental research design by utilizing the functions of an Electromagnetic Induction Device (EID) comprised of a 12v motor battery, light bulb, coiled wire, and switch. The EID was turned on for 10 minutes every day where the electric volts generated by the 12v motor battery were transported through the coiled wire and distributed to the metallic iron screen surrounding the area of the experimental group. The data gathered during the 12-day observation of the growth of radish (Raphanus sativus) were tabulated, analyzed, and evaluated using mean tests, standard deviation, and T-test. Based on the result and analyses of the gathered data, it was found that the experimental group, the one with the presence of induced magnetism, surpassed the control group in terms of growth speed, shoot growth, and overall seed development. However, it was also revealed that in terms of growth rate, there is no significant difference between the control group and experimental group. Therefore, the utilization of Induced Magnetism on the seed germination of radish (Raphanus sativus) is effective in terms of growth speed, shoot growth, and overall development.

Keywords: *Induced magnetism, Electromagnetic Induction Device (EID)*

INTRODUCTION

The geomagnetic field, commonly known as the Earth's magnetic field, is responsible for the magnetic field that extends from the Earth's interior into space, where it interacts with the solar wind, a stream of charged particles emitted by the sun. Plants, which are known to perceive various wavelengths of light, respond to gravity, touch, and electrical communication, positively react to it, and grow faster. Krylov and Tarakonova in 1960 were among the first to investigate the effects of a magnetic field on plants in their study of Plant Physiology, where there is an auxin-like action of a magnetic field proposed to explain tomato fruit ripening (Agritech Tomorrow, 2020).

The discovery of chemical fertilizers played a major yield-enhancing component in plant cultivation. However, the present usage of chemical fertilizers and other materials has been contentious, directing the use of alternative environmentally friendly treatments utilizing electric voltage to fertilize and enrich soil components (Aladjadjiyan, 2020). In the short term, chemical fertilizers enable farmers to produce more and higher-quality crops. Still, they may result in fewer or lower-quality crops over the long run (The Hidden Dangers of Chemical Fertilizers, 2018). They frequently affect the stability of the soil aggregate, the ability to retain water, the rate of infiltration, porosity, hydraulic conductivity, and bulk density. The Fertilizer Industry and Philippine Agriculture: Policies, Problems, and Priorities (2017) states that the Philippines' most popular and commonly used fertilizers are nitrogen fertilizers that contain higher salt indexes that affect the ability of the seedling to absorb water, causing seedling desiccation.

Aleosan, a municipality in North Cotabato, is a progressive agricultural community. The Municipality of Aleosan encourages more farmers to integrate organic farming due to the need to increase its agricultural potential in terms of high-value crops and animals (Municipal Government of Aleosan, 2019). However, Aleosan's present soil sustainability troubles germinating radish (*Raphanus sativus*) seeds because of the long-run effect of chemical fertilizers. Therefore, induced magnetism is an interesting alternative to chemical approaches as the Municipality of Aleosan searches for new ecological and cost-effective ways to improve the performance and potential of germinating radish seeds.

For decades, the intensive use of the Magnetic Field has revolutionized the human environment. It brought a lot of significance, especially in the field of agriculture (Kataria, 2019). There is already solid evidence that magnetic pre-germination treatment of seeds before sowing reduces planting expenses by significantly increasing germination rates. However, no clear studies are basing on radish (Raphanus sativus) seeds in applying this method to its germination process. Hence, the researchers will utilize induced magnetism effectively in the germination of radish (Raphanus sativus) seeds in terms of its growth rate, growth speed, and shoot growth.

Objectives

This study aimed to utilize induced magnetism to effectively influence the germination of Radish (*Raphanus sativus)* seeds.

Specifically, it aimed to:

1. develop a magnetic field enclosed area that would contribute to the germination of Radish (*Raphanus sativus)* seeds;
2. determine the effectiveness of induced magnetism on the Radish (*Raphanus sativus)* seeds between the control and experimental group in terms of:
    a. growth rate,
    b. growth speed, and
    c. shoot growth; and
3. determine if there is a significant difference on the effectiveness of induced magnetism in the germination of the seed between the control and experimental group in terms of: a. growth rate,

b. growth speed, and

c. shoot growth.

4. determine if there is a significant difference in the overall development in the germination of the seed between the control and experimental groups.

a. growth speed, and shoot growth

METHODS
Research Design

This study utilized an experimental research design. The study had a control and experimental group (independent variables) that examined the effectiveness of utilizing induced magnetism (dependent variable) on the seed germination and development of Radish (*Raphanus sativus*) seeds.

Population and Sampling

The research respondents were exclusively composed of the researchers. This was to ensure the reliability of data gatherings. The respondents measured the seed's growth rate, growth speed, and shoot growth.

Instrumentation

This study used an observation table to gather and record the growth rate, growth speed, and shoot growth of the control and experimental groups. To get the appropriate data needed, the researchers used their observations. The researchers gathered all the test findings and analyze them to see the effectiveness of the induced magnetism on the radish seed.

List of Materials

Plate 1. Motor Battery

Plate 2. Radish Seeds

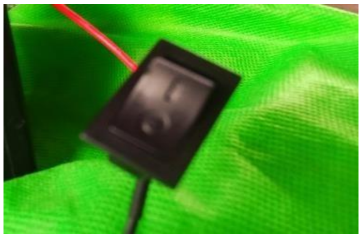


Plate 3. Switch

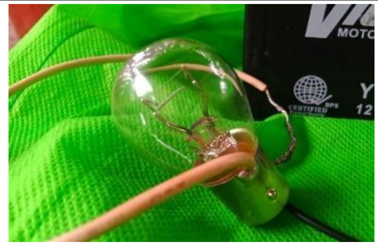


Plate 4. Light Bulb

Plate 5. Rectangular Wooden Container

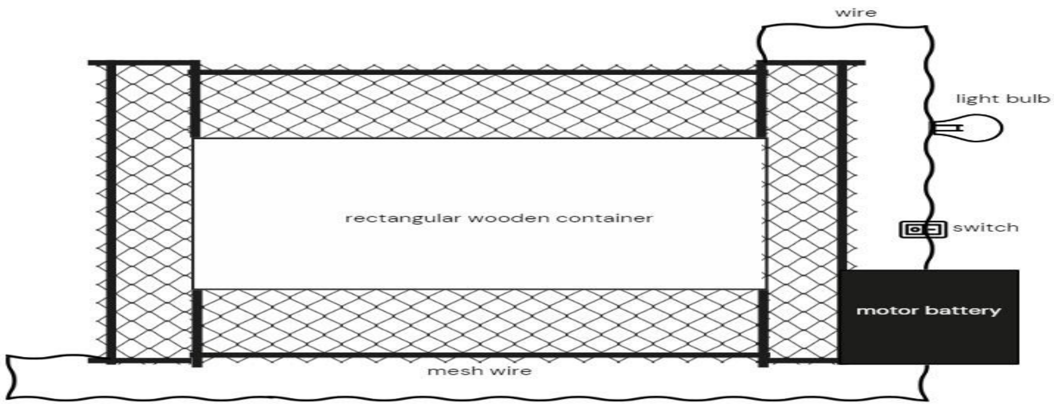
Plate 6. Coiled Wire

Plate 7. Soil

Plate 8. Measuring Cup with 30 ml of Water

Plate 9. Mesh Wire

Blueprint Structure of the Device



General Procedure

Plant growth can be accelerated by hundreds of percent by the smart application of energy in the forms of static electricity from batteries as easily accessed stored energy materials. The energies applied to the seeds, plants, and soil positively affects the plants' seed germination.

Step 1. Collecting and Gathering of Materials

To collect the materials needed and necessary to make and construct the EID (Electromagnetic Induction Device) the researchers gathered a 12v motor battery, light bulb, mesh wire, switch, rectangular glass container, radish seeds, soil, and measuring cup with 30 ml of water.

Step 2. Constructing the Electromagnetic Induction Device (EID)

The Electromagnetic Induction Device was constructed with the help of an expert in the field of electronics. The researchers requested the assistance of Mr. Melben C. Talha in soldering and assembling the EID (Electromagnetic Induction Device). The electric volts generated by the 12v motor battery were distributed to the metallic iron screen surrounding the area of the experimental group.

Step 3. Forming the Overall Structure of the Independent Variables (Control Group and Experimental Group)

After constructing the EID (Electromagnetic Induction Device), the researchers formed the overall structure of the independent variables. The control group consisted of a rectangular glass container, soil, water, and radish seeds. The experimental group consisted of a rectangular glass container, soil, water, radish seeds, and the EID (Electromagnetic Induction Device). The researchers assembled the independent variables and put them in an area with the same growth factors.

Step 4. Planting Radish (*Raphanus sativus*) Seed

After preparing the independent variables, the next step was planting the radish seeds into the two groups. The researchers planted the radish seeds 2 inches beneath the ground within the rectangular glass container, and the researchers planted 20 radish seeds 4 inches apart. After planting and finalizing the arrangement of the radish seeds, it was watered with 30 ml of water twice a day.

Step 5. Observing the Early Growth Rate and Germination of the Radish *(Raphanus sativus)* Seed

The researchers had observed the early growth rate and germination of the radish seed in a span of 21 days. Each day, the EID (Electromagnetic Induction Device) was turned on for only 10 minutes at 10:00 – 10:10 AM to transport electricity to the metallic iron screen that was distributed to the area surrounding the Radish (*Raphanus Sativus*) seeds. The light bulb was the main indicator that electricity was present, and the device was working. The researchers included an observation table that involved the Dependent Variables (Growth Speed, Growth Rate, and Shoot Growth). Every week, the researchers had observed the germination of the Radish (*Raphanus sativus*) seed and gathered all the information needed.

Data Gathering Procedure

Seeking Permission for the Conduct of the Study

Administering the Structured Observation Sheet

Interpreting and Analyzing the Data Gathered

Determine the Effectiveness of the Experiment

Flow chart of the Data Gathering Procedure

Step 1: Seeking Permission for the Conduct of the Study

The actual data collection proceeded when the researchers have submitted the letter of permission for the study to Mr. Raffy S. Virtucio, MEAL, LPT, the Senior High School Principal, for approval.

Step 2: Completing the Structured Observation Sheet

The researchers then recorded an observation table they had prepared.

Step 3: Interpreting and Analyzing the Data Gathered

Following the extraction of the study's findings, the researchers collected and organized the data in Microsoft Excel. The output or the data obtained was examined using statistical measures.

Step 4: Determine the Effectivity of the Experiment

Finally, the research output was examined to see the effectiveness of induced magnetism on the seed germination of radish (*Raphanus sativus*) based on the experiment results. Following that, the researchers developed their conclusions and suggestions.

Data Analysis

The result of the observations was tabulated, computed, and evaluated using descriptive statistics such as mean and standard deviation in determining the development of the radish (Raphanus sativus) seed between the control and experimental group. The development of the radish (Raphanus sativus) seed with induced magnetism was indicated by the growth rate, growth speed, shoot growth, and the overall seed development. Growth rate was analyzed by the percentage of the seeds that successfully germinated. Growth speed was analyzed by the span of the days that the seed had germinated between the control and experimental group. Shoot growth was interpreted according to the number of shoots in a span of 12 observation days. The same statistical tool was used in determining the overall seed development. T-test was used to determine the significant difference in the germination of the radish (Raphanus sativus) seeds between the control and experimental groups.

RESULTS and DISCUSSION

Growth Rate

Table 1.1 shows the growth rate output of the control group and experimental group. The growth rate output was measured every 3 days in a span of 12 days by recording the number of growing *Raphanus sativus.*

Table 1.1. Mean growth rate outputs of control and experimental group in 12 days.

Growth Rate	1	2	3	4	Mean Growth Rate
Control Group	20 (100%)	20 (100%)	20 (100%)	18 (90%)	97.5%
Experimental Group	20 (100%)	20 (100%)	20 (100%)	20 (100%)	100%

Table 1.1 above indicates that in 12 days of data gathering, the number of *Raphanus sativus* in the Experimental Group have a total of 20 plants on day 3; 20 plants on day 6; 20 plants on day 9; and 20 plants on day 12. The Control Group also had 20 plants on day 3; 20 plants on day 6; 20 plants on day 9; and 18 plants on day 12. It shows that the Experimental Group had an average of 100% of the number of *Raphanus ativus* plants from the beginning of the observation to the end while the Control Group had an average of 97.5%.

Additionally, the growth rate in comparison with the control and experimental group did not have much of a difference as according to the agriculturist, Reme Mostrales, seeds that are bought directly from Seedlings Company are guaranteed to have a growth rate of 98-99%, specifically Ramgo seeds.

Growth Speed

Table 1.2 shows the growth speed of the control group and experimental group. The growth speed was measured every 3 days in a span of 12 days using a ruler.

Table 1.2. Mean growth speed outputs of control and experimental group.

Growth Speed	1	2	3	4	Mean
Control Group	7.63 cm	10.38 cm	12.616 cm	12.872 cm	10.8745 cm
Experimental Group	10.48 cm	16.28 cm	17.78 cm	19.68 cm	16.0550 cm

Table 1.2 above indicates that in 12 days of data gathering, the Experimental Group reached an average height of 16.0550 cm, while the Control Group reached an average height of

10.8745 cm. It further shows that the Experimental Group's growth speed was significantly faster than that of the Control Group.

This result proved what MDPI posited, as cited by Sarraf et al. (2020), that the agronomic use of magnetic field in plants can change current plant production methods, increase root, and shoot development, have high productivity, have more photosynthetic pigment content, and have more intense cell division as well as water and nutrient uptake in a faster period compared to the normally planted seeds. Thus, with the presence of induce magnetism applied to the seeds, the growth speed was immensely faster.

Shoot Growth

Table 1.3 shows the shoot growth of the control group and experimental group. The shoot growth was measured every 3 days in a span of 12 days using a ruler.

Table 1.3. Mean shoot growth of control and experimental group.

Shoot Growth	1	2	3	4	Mean
Control Group	2.55 cm	5.3 cm	7.5 cm	9.3 cm	6.1625 cm
Experimental Group	5.4 cm	11.2 cm	12.7 cm	14.6 cm	10.9750 cm

Table 1.3 above indicates that in 12 days of data gathering, the shoot growth of the Experimental Group reached an average height of 10.9750 cm, while the Control Group reached an average height of 6.1625 cm. It further shows that the Experimental Group reached a greater height of shoot growth in a span of 12 days compared to the Control Group. Further, as quoted by Zehra et al. (2021), "elicitors are agents that induce plant defense responses". With this, electricity generates elicitors, which put seedlings under stress and stimulate them to fight back and develop outwardly. As electricity reaches the soil it releases electric voltage that increase the synthesis of what we call proteins present in soil. These proteins are called, "detrital proteins" which are characterized to the Alanine, Asparagine, and the Histidine. This result proved the statement of Sarraf et al. (2022), that the increase in the intensity of the Magnetic Field (MF) plays a vital role in the plant's growth.

Significant Difference between the Control and Experimental Group in terms of Growth Rate

Table 2.1 shows the T-test on the effectiveness of induced magnetism in the germination of the *Raphanus sativus* seed between the control and experimental group in terms of growth rate. The results revealed that the computed value of p is equal to 0.355918. Since it is more than the 0.05 level of significance, Ho_1 is therefore accepted. This implies that there is no significant difference in the germination of the *Raphanus sativus* seed between the control and experimental group in terms of growth rate.

Moreover, it is evident that the results in Table 2.1 proves the statement of Berger (2021), in his book entitled, "The Effects of Neodymium Magnets on Plant Growth", on how treated plants are only affected on their naturally present magnetic field intensity, such as their metabolism rate. With this, the growth rate is not significantly affected which coincides with the statistical results. Furthermore, as mentioned in Table 1.1, with or without the presence of induced magnetism when planted, there is a 98-99% growth rate for plants bought directly from Seedlings Company, as said by the agriculturist.

Table 2.1. T-test on the effectivity of Induced Magnetism on the Control and Experimental Group in terms of growth rate.

Growth Rate						
	Mean	SD	p-value	t-value	Result	Decision
Control Group	97.50	5.00	0.355918^{**}	-1.0000	not significant	Accept Ho_1
Experimental Group	100	0				

**Significant at a = 0.05

Significant difference on the Effectiveness of Induced Magnetism in the Germination of the *Raphanus sativus* seed between the Control and Experimental group in terms of Growth Speed

Table 2.2 shows the T-test on the effectiveness of induced magnetism in the germination of the *Raphanus sativus* seed between the control and experimental group in terms of growth speed. The results revealed that the computed value of p is equal to 0.033933 and there is a significant difference between control and experimental group. Since it is lesser than the 0.05 level of significance, Ho_2 is therefore rejected. This implies that the use of induced magnetism influences the growth speed of *Raphanus sativus*. Therefore, the experimental group is faster than the control group in terms of growth speed since there is a significant difference in the t-test done.

Additionally, the results aligned with the study of Barinov (2012), specifically on "The Effect of Electricity on Plant Growth" as he stated how the magnetic field increases the current flow around the area, stimulates the plant's growth, shields plants from pests and contaminations through the method of electroculture and as quoted, "developing a greater and better harvests in less time span, with less exertion, and expenses". Supplementary to that, the method of electroculture generated an increased electric field on plant growth as supported by Xunjia et al. (2022) book entitled "Stimulation of ambient energy generated electric field on crop plant growth", which proves how the *Raphanus Sativus'* speed of growth was greater with induced magnetism than that of the control group. In line with this, Fu (2012) have discovered that, when it comes to plant height, leaf size, and a few other key indicators of their health, plants that are exposed to magnetic fields tend to grow faster, taller, bigger, and healthier.

Table 2.2. T-test on the effectivity of Induced Magnetism on the Control and Experimental Group in terms of growth speed.

Growth Speed

	Mean	SD	p-value	t-value	Result	Decision
Control Group	10.81	2.56				
Experimental Group	16.06	3.97	0.033933**	-2.22354	Significant	Reject Ho2

**Significant at a = 0.05

Significant difference on the Effectiveness of Induced Magnetism in the Germination of the *Raphanus sativus* seed between the Control and Experimental Group in terms of Shoot Growth

Table 2.3 shows the T-test on the effectiveness of induced magnetism in the germination of the *Raphanus sativus* seed between the control and experimental group in terms of shoot growth. The results revealed that the computed value of p is equal to 0.4919. Since it is lesser than the 0.05 level of significance, Ho_3 is therefore rejected. This implies that there is a significant difference in the measurement of shoot growth. Therefore, the experimental group is significantly higher than the control group in terms of shoot growth since there is a significant difference in the t-test done.

With the t-test's results, the shoot growth was immensely greater than that of the control group due to how the external intensity of Magnetic Field fuels varying physiological responses on plants most specifically its "…activation of cryptochrome, and shoot growth", as one of its stated responses, as cited by Maffei (2014), in his study entitled, "Magnetic field effects on plant growth, development, and evolution". Indeed, it justifies how Table 2.3's results are significantly effective in the application of the induced magnetism in its shoot growth.

Table 2.3. T-test on the effectivity of Induced Magnetism on the Control and Experimental Group in terms of shoot growth.

Shoot Growth	Mean	SD	p-value	t-value	Result	Decision
Control Group	6.16	2.91				
Experimental Group	10.98	3.97	0.4919**	-1.95556	Significant	Reject Ho_3

**Significant at a = 0.05

Significant difference on the Effectiveness of Induced Magnetism in the Germination of the *Raphanus sativus* seed between the Control and Experimental Group in terms of Overall Seed Development

Table 2.4 shows the T-test on the effectiveness of induced magnetism in the germination of the *Raphanus sativus* seed between the control and experimental group in terms of overall seed development. The results revealed that the computed value of P is less than 0.0001. Since it is lesser than the 0.05 level of significance, Ho_2, Ho_3 and Ho_4 are therefore rejected. This implies that there is a significant difference in the effectivity of growth speed, shoot growth, and overall seed development. Therefore, the Experimental Group is more effective than the control group in terms of shoot growth, growth speed and overall seed development since there is a significant difference in the t-test done.

In addition, with the t-test results, the table proved significant in its overall seed development, compared to the experimental group, due to how the main indicators of the effectiveness of the induced magnetism is only consisted of its growth speed and shoot growth, putting aside the growth rate which is not affected by the induced magnetism as it is guaranteed and established to have a 98-99% growth rate by Seedlings Company, as stated by Reme Mostrales, the study's agriculturist. Furthermore, the results proved Berger (2021) once again and his statement on how plants are extremely sensitive to the presence of magnetic field, as to how their cells' powerhouse, the mitochondria, reacts, which contains the cryptochromes that aids the plant's growth. Likewise, the results also put into significance how the spaces between the seeds when planting contributed for its proper maturation, on how they should be 4 inches apart, as mentioned in the study about the "8 Truths About Growing Radishes" by Pleasant (2017). With that, the t-test results are significant and is plausible.

Table 2.4. T-test on the effectivity of Induced Magnetism on the Experimental and Control Group in terms of overall seed development.

Overall, Seed Development	Mean	SD	p-value	t-value	Result	Decision
Control Group	8.52	2.66 3.97	0.40721^{**}	-2.09139	Significant	Reject Ho_4
Experimental Group	13.52					

**Significant at a = 0.05.

CONCLUSIONS

The data gathered during the 12-day observation of the growth of radish (Raphanus sativus) were tabulated, analyzed, and evaluated using mean tests, standard deviation, and T-test. Based on the result and analyses of the gathered data, it is concluded that the experimental group, the one with the presence of induced magnetism, surpassed the control group in terms of growth speed, shoot growth, and overall seed development. However, it is revealed that in terms of growth rate, there is no significant difference between the control group and experimental group. Therefore, the utilization of Induced Magnetism on the seed germination of radish (Raphanus sativus) is effective in terms of growth speed, shoot growth, and overall development.

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