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Preliminary study on the effect of extremely low frequency magnetic field on the growth of adzuki bean plant

By

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Abstract:

Plant growth is influenced by many factors, including environmental factors. However there are still uncertainties as to whether plants that are exposed to magnetic field experience biological effects and thus influenced plant growth. This paper describes the effect of extremely low frequency magnetic field on plant growth. Helmholtz coils were used to generate the magnetic field and adzuki bean (*Vigna Angularis*) or also known as red bean plants were chosen as subject. The power frequency magnetic field at 50 Hz and magnetic flux density of 83 µT was used. Measured parameters were the height of the stems and the number of leaves produced. The growing rates of adzuki bean plants were observed every 2 days for 22 days. The experimental results indicated that magnetic fields do influence plant growth. These findings could be useful in developing ways to use magnetic field to enhance plant growth, which could help to increase productivity.

Keywords:

Magnetic Field, Electric Field, Biological Effect and Plants Development.

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1. Introduction:

The effect of electric and magnetic fields (EMF) on biological systems and human being is a subject of considerable concern and investigation. EMF is an inescapable environmental factor for humans and plants and especially the exposures to man-made EMF have steadily increased due to increased demand for electricity. There have been several studies on the effects of EMF, especially the electric component of it on plants [1-4]. However the biological effects of EMF on plants are still not properly understood.

Research of magnetic field effects on plants have been done to various types of plants such as bean sprouts, cucumber and alaska pea [5-7]. If the experimental configuration of biological effects on plants is well defined in terms of the magnetic field, it could provide unique opportunities. Light, gravity and humidity are, of course, more overwhelming factors for plants. However magnetic field components could be displayed by altering the biological effects of other dominant factors, when the magnetic environment is a controlled experimental parameter. In order to examine the growth of plants, growth of the adzuki bean plant were examined under influence of magnetic field. Moreover, such growth was compared with the growth under normal environmental conditions. This paper describes several fundamental features of plant growth that were compared between magnetic environment and under normal environmental conditions.

2. Description of Adzuki Bean Plant:

Adzuki beans (*Vigna Angularis*) are small oval beans approximately 5 mm in diameter [8-10]. They are variously colored, but most often dark red. Types with green, straw-colored, black-orange, and mottled seeds are also known. The round seeds have a hilum (seed scar) with a protruding ridge on the side. Figure 1 below shows the adzuki beans.

Figure (1): *Adzuki beans*

Adzuki bean plant is erect, 1-2 feet high, although some gardeners have reported them to be indeterminate. The yellow flowers are followed by a cluster of several smooth, short, small, cylindrical pods. Leaves resemble those of Southern peas, while the pods are much like mung bean pods.

Adzuki bean is a legume. It germinates by epicotyls growth, leaving the cotyledons below the soil surface. They have an indeterminate growth habit which results in completely mature pods (1/8 inch diameter by 5 inches long), brownish in color, along with slightly yellow and completely green pods on each plant. Plants generally mature in 110 to 120 days after planting and are 18-25 inches tall. However for this study, the growths of adzuki bean for its first 22 days were examined under the influence of magnetic field. The known maximum growth height of adzuki bean plant during mature is necessary for the dimension of test rig to be design and constructed for this study.

The soil and plant should be prepared properly. Seeds are sow ¾-1 inch deep, thinning the plants to stand about 2-3 inches apart in the row. Space rows 12-18 inches apart. Ordinary care is given during its growth. Adzuki is said to be fairly drought resistant, although the soil moisture should be maintained at a consistent level.

The ripe seeds contain 25% protein and are highly nutritious. Also, the seeds are used primarily as a dry bean, for sprouts, whole, or ground into bean meal, but many cooks use them green. Since they have a sweeter taste than most beans, they are sometimes used in desserts. Table 1 below shows the scientific classification of adzuki bean.

Table (1): *Scientific classification of adzuki bean*

Scientific Classification	
Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Tribe:	Phaseoleae
Genus:	Vigna
Species:	V. Angularis
Binomial Name	
Vigna Angularis	

3. Description of the Test Rig:

The most important element in the test rig is the generation of uniform magnetic field throughout a certain location where the adzuki bean plants are to be planted. This can be achieved using Helmholtz coil. A Helmholtz pair consists of two identical circular magnetic coils that are placed symmetrically one on each side along a common axis. If the current in each coil is identical, and flows in the same direction, the axial component of the magnetic field is equal to the sum of the magnetic field of the two coils. This is given by:

$$\mathbf{B} = \frac{\mu_0 N I R_0^2}{2\left[R_0^2 + \left(\frac{d}{2} + x\right)^2\right]^{3/2}} + \frac{\mu_0 N I R_0^2}{2\left[R_0^2 + \left(\frac{d}{2} - x\right)^2\right]^{3/2}} \qquad (1)$$

where,

μ_0 = magnetic permeability of free space = $4\pi \times 10^{-7}$ H/m
I = coil current, in amperes
R_0 = coil radius, in meters
x = distance from centre of 2 coils, in meters
d = separation distance of the coils, in meters
N = number of turns of wire

A particularly useful configuration occurs when the two coils are separated by their radius ($d = R_0$). The magnetic flux density at the center of the coils (when x = 0), becomes:

$$\mathbf{B} = \frac{(32\pi \times 10^{-7})\, NI}{5^{3/2}\, R_0} \tag{2}$$

To suit the dimensions of the adzuki bean plant coil radius of 0.47 m and 14 turns of wire were selected. A maximum magnetic flux density of 83μT was obtained from the test rig and this value was used for the experiment. The test rig is shown in Figure 2.

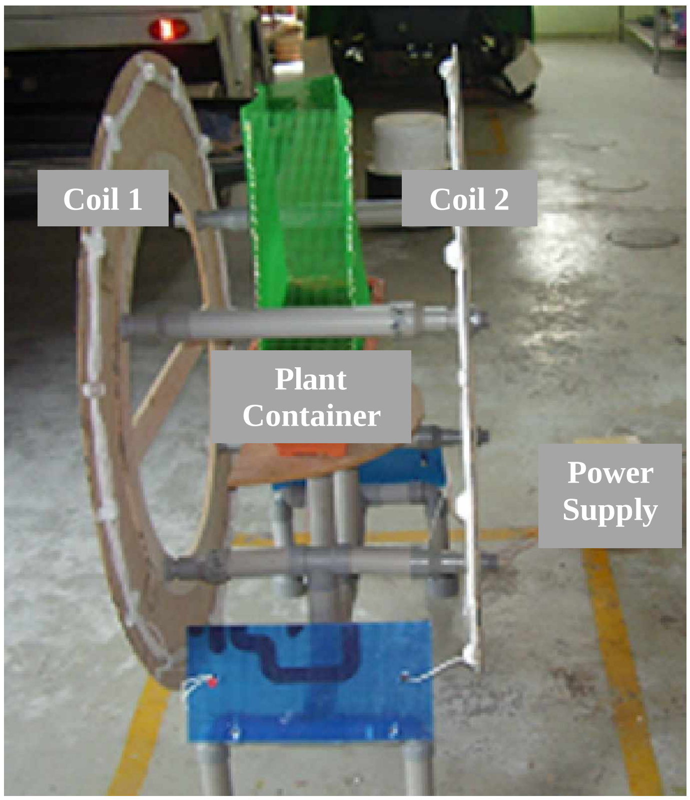

***Figure (2):** Helmholtz coil with platform for plant container*

4. Experimental Results:

Experiments were conducted to check on the percentage of germination of the adzuki bean seeds. Twenty seeds were embedded into the soil in the containers and kept under normal condition to observe how many out of 20 seeds that will grow. Cares were taken to make sure that only good seeds were used throughout this experiment.

For every round of experiments, 20 adzuki bean seeds were embedded in the soil already treated with inorganic fertilizer on each of the two containers. Immediate watering of the soils was carried out to moisten it and also help to enhance the germination process of the seeds. Photo showing the two containers containing seeds of adzuki bean plant is as shown in Figure 3 below.

Figure (3): *Containers containing seeds of adzuki bean*

The first container was exposed to magnetic field of 83 µT by placing it within the Helhmoltz coil. The second container was located away from any known sources of magnetic field and thus acts as control. The growing rates of adzuki bean plants were observed for every 2 days for 22 days. Watering of the plants was carried out two days once. 250 ml of tap water were sprinkled such that it will be equally distributed among seeds within the container and were done for both containers. Magnetic field readings were taken for every 2 days to make sure that the field is always constant.

Based on the observations, the percentage of germination of the plant seeds is 50% for both conditions. It is to say that for every 20 seeds planted, only 10 would grow. Studies shows that the possible reasons are due to the seeds itself, soil and the watering technique. Other main reasons are the sunlight and heat [8-10].

Two sets of experiments were conducted. Observations were done on the plant height. Readings were taken for every alternate day. Figure 4 shows plants height after 9 days for experiment 2. **C**omparisons of plant height for both experiments are as shown in Figure 5 and Figure 6 respectively.

Within the coil: 12 cm long Control: 8cm long

Figure (4): *Comparison of plants height after 9 days for experiment 2*

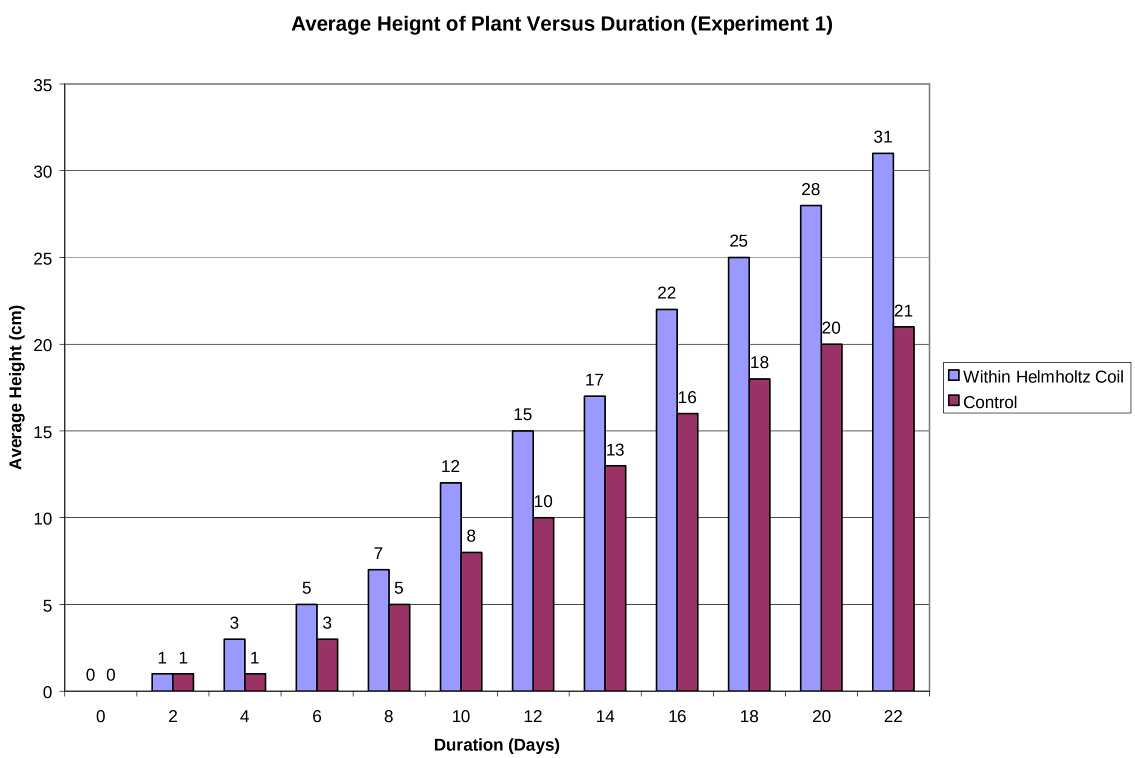

Figure (5): *Comparison of height versus duration for experiment 1*

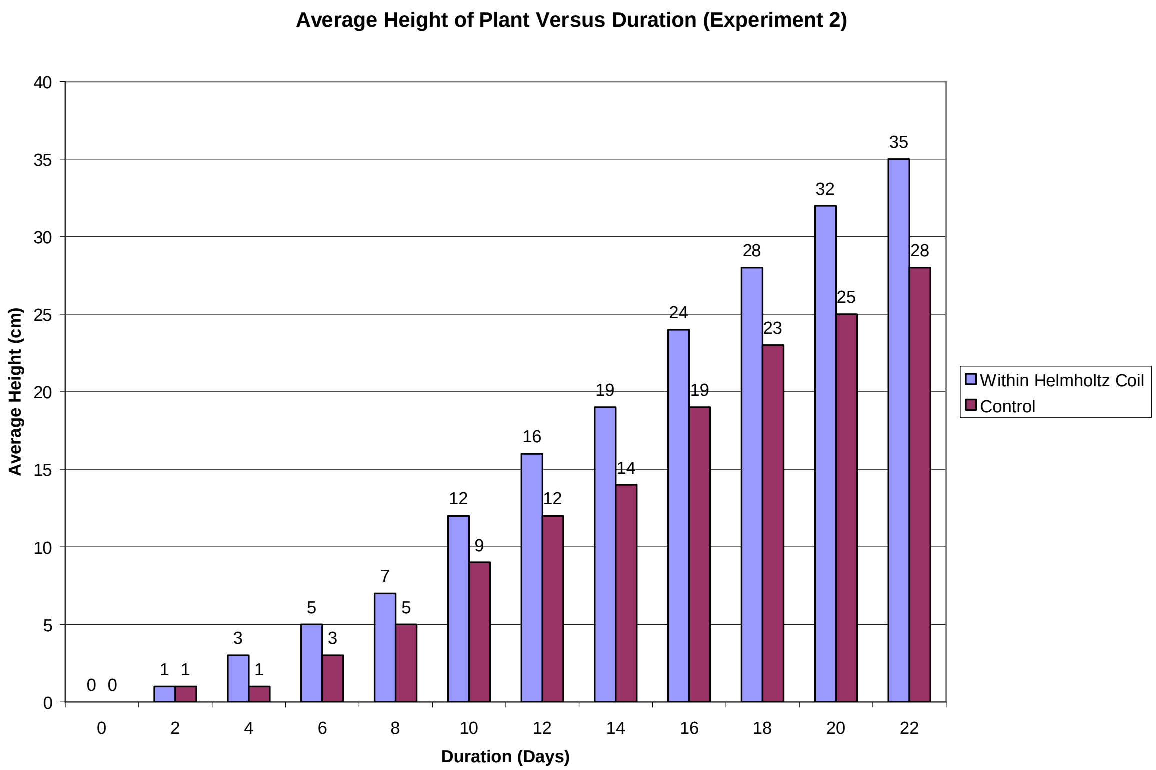

Figure (6): *Comparison of height versus duration for experiment 2*

The result shows that the height of the adzuki bean plant under the influence of magnetic field is higher as compared to the plant without magnetic filed (control). This shows that magnetic field does enhance the growth of the adzuki bean plants.

Another observation was done on the total number of leaves on the plants. Data was taken every alternate day to check the total number of leaves produced by the plant. Results for both experiments are as shown in Figure 7 and Figure 8 respectively.

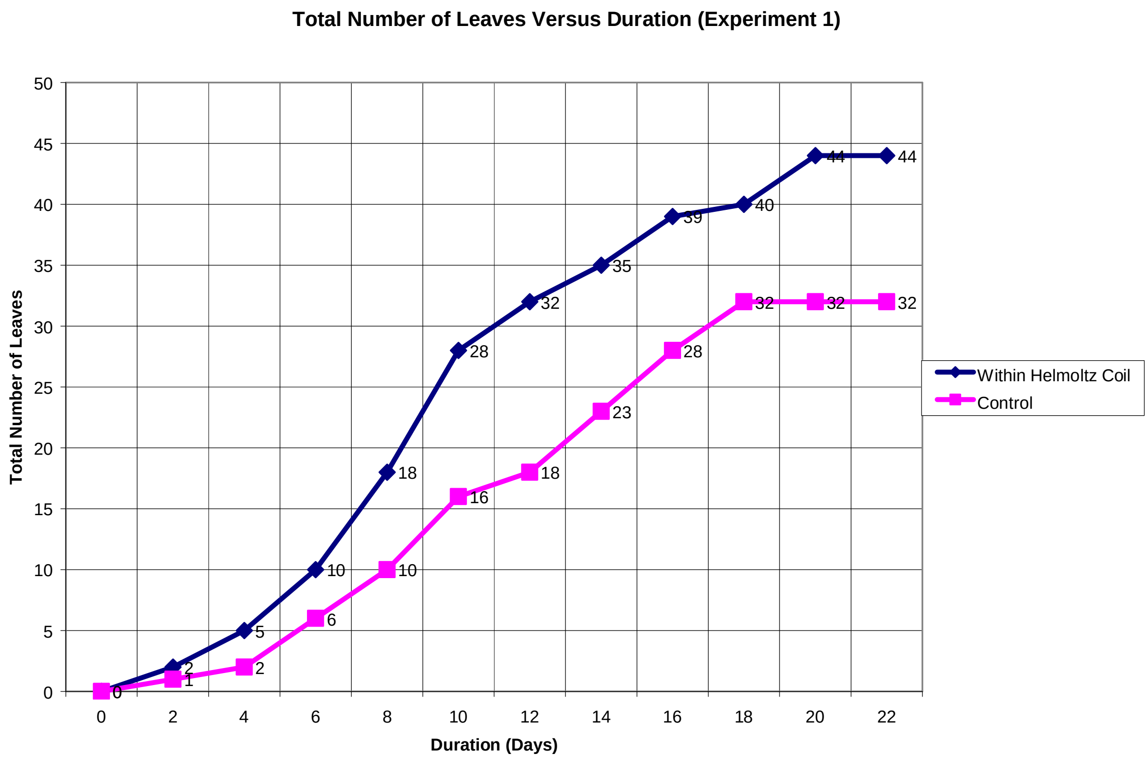

Figure (7): *Comparison of number of leaves versus duration for experiment 1*

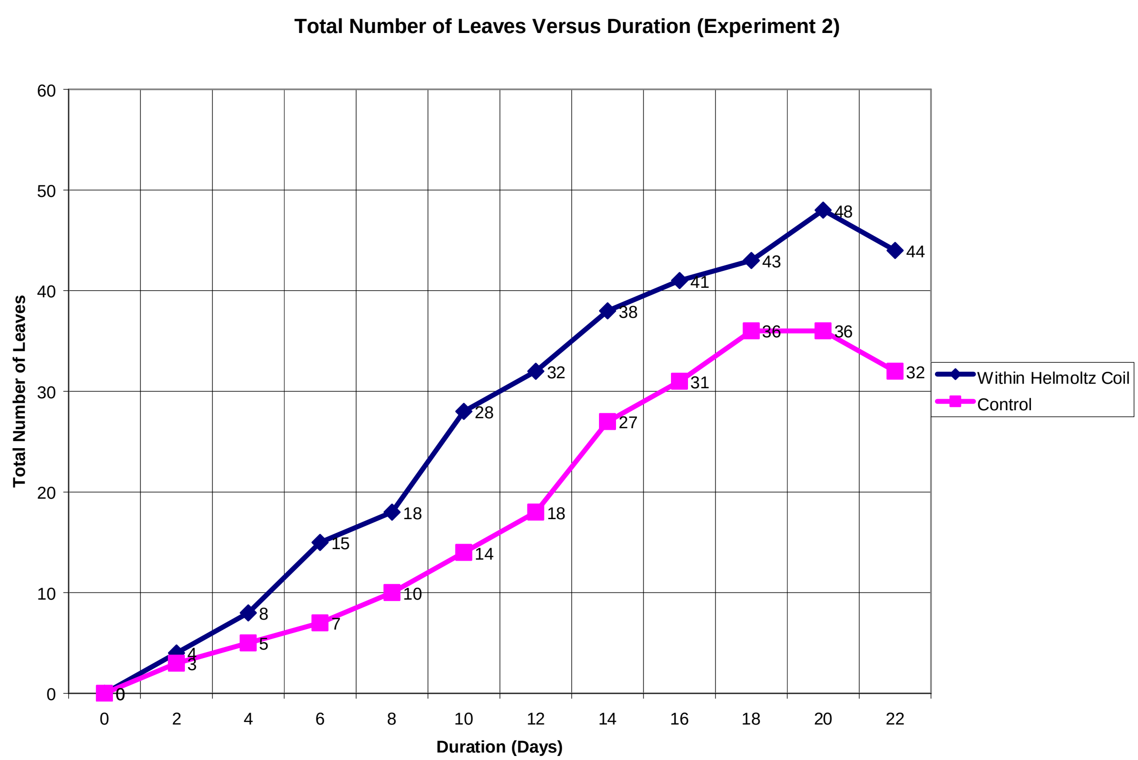

Figure (8): *Comparison of number of leaves versus duration for experiment 2*

The result shows that there were more leaves for plants under the influenced of magnetic field as compared to the plants under normal environmental conditions. Also their leaves are bigger and look fresh under the influence of magnetic field. For the control experiment their leaves are a bit smaller and less healthy. This indicates that adzuki bean plant under the influenced of magnetic field have better growth compared to the plant under normal environmental conditions.

5. Discussion and Conclusion:

A uniform magnetic field was obtained from the Helmholtz coil and formed as a test rig for this study. Based on the controlled amount of current which were allows to flow into the Helhmoltz Coil, the desired magnetic flux density was obtained. A maximum magnetic flux density of 83µT was obtained from the test rig and this value was used for the experiment.

The adzuki bean plants experienced growth both under the influence of magnetic field and normal environmental condition. From these experiments, results shows that the plants with the influenced of magnetic field has a higher growth rate as compared to the one under normal condition. This shows that magnetic field does enhance or promote the growth of the bean plant. It was also observed that there are more numbers of leaves in the plant under the influence of magnetic field as compared to the plant under normal environmental conditions. Further studies need to be done to evaluate the rate of plant growth with different values of magnetic field densities. Findings could be useful in developing ways to use magnetic field to enhance plant growth, which could help to increase productivity.

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Nomenclatures:

B … magnetic flux density
μ_0 … magnetic permeability of free space = $4\pi \times 10^{-7}$ H/m
I … coil current, in amperes
R_0 … coil radius, in meters
x … distance from centre of 2 coils, in meters
d … separation distance of the coils, in meters
N … number of turns of wire