Effects of Electromagnetic Field on the Growth of Kidney Beans

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***Abstract*—Experimental investigations of the impact of high-frequency, low-intensity electromagnetic (EM) fields on the morphometric growth parameters of kidney bean plants were carried out. In recent years, there has been an increase in the use of various electronic devices. However, individuals who are in proximity of these devices do not realize the adverse effects of these devices on human health. Therefore, this study investigated the effects of EM field on growing cells of the kidney bean plant.**

***Index Terms*—Electromagnetic Field; Kidney Beans; Morphometric; Parameters.**

I. INTRODUCTION

The electromagnetic (EM) environment is a very important issue in the operation of many devices such as home appliances, office equipment, mobile phones, and electric vehicles [1]-[9]. Therefore, many countries strictly regulate EM field exposure levels for humans in accordance with the guidelines of the International Electrotechnical Commission (IEC) [10], [11] and the International Commission on Non-ionizing Radiation Protection (ICNIRP) [12]. Various methods have been studied to reduce EM exposure [13], [14].

Among these methods, using heterogeneous anatomically derived models of the head, Gandhi [15] reported that exposure increases at a compounding rate of 10%-15% for every millimeter closer to the radiating antenna. The physical reason for this rapid drop-off of coupled energy is that the radio-frequency EM fields close to the radiating source (the so-called near-field region) reduce in strength very rapidly, even faster than in the far-field region, where the EM fields decrease inversely with the square of the distance from the source.

Research into the distance at which EM waves from an electrical appliance affect humans is ongoing. Clear identification of the direct effects of EM waves on the human body is not easy, because of environmental factors and the differences among individuals. However, continuous exposure to EM waves might be harmful to the human body. For this reason, we must solve the problems caused by EM waves. A great deal of research has been performed regarding providing alternatives when protecting people from EM waves. However, there is still no alternative with a substantial blocking effect, because of the limitations imposed by the international review board for protection of humans.

As a method for determining the extent to which an EM field affects cells, this paper evaluates the effects on growth, which is one of the functions of a cell. In this experiment, a plant, rather than an animal, is chosen because it is easy to test and observe its growth. This paper investigates the growth of kidney bean plants, and, through the investigation, the effects of EM waves on plant growth are derived and the associated problems are addressed.

II. GROWTH OF KIDNEY BEAN PLANTS

To ensure the plant grows well and the bean can be peeled gently, test kidney beans were placed in water and macerated. When germination starts, the kidney beans are moved and planted in pots to begin the population experiment. Two boxes (30 cm x 45 cm) were constructed using acrylic plates and their front and upper sides were removed to maintain a constant amount of sunshine (Figure 1).

(a) Kidney beans germination

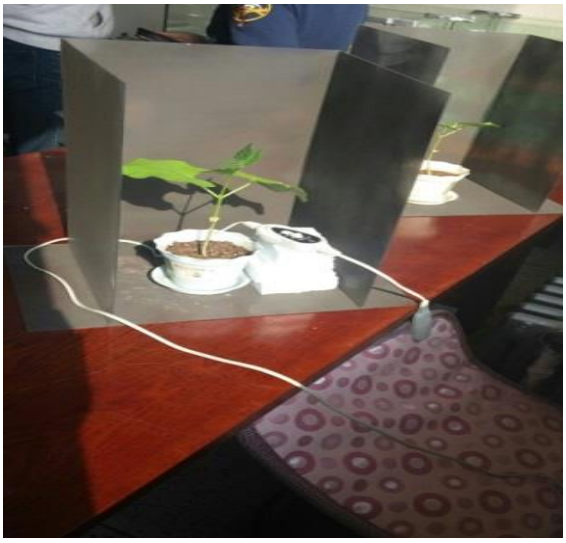
(b) Transplanting kidney beans to flowerpot

(c) Test box for a constant sunshine amount

Figure 1: Kidney bean germination, transplanting to pot, and test Box for a constant sunshine amount.

In a laboratory experiment conducted at constant temperature and humidity, two boxes were placed at a 30-cm gap in a position such that they received maximum sunlight. A masking reagent (NSC400H, ELECTROLUBE) was applied to the inner surface to minimize influx of leaked and external EM waves. Five populations were selected as a control group; the control group establishes a standard stem height and size of the grown kidney leaf. The population is located at the same position in the boxes with field exposure and no field exposure.

To establish different experimental conditions, a temperature control switch of the electric blanket (BKC-12 CS01, Bokuk, Korea) was placed on right side of the left box, at its center (for artificially generating the EM wave), as shown in Figure 2(a). From the other side of the box, all devices capable of generating an EM wave were removed from a 30-cm radius surrounding the box, to minimize the occurrence of EM waves, as shown in Figure 2(b).



(a) Exposure to the electromagnetic wave

(b) Non-exposure to the electromagnetic waves

Figure 2: Control group

The advantages of using a temperature control switch of an electric blanket include easy installation and cost-effectiveness, and because it emits a relatively large EM field. During the pretesting of the field of EM waves measured using an ME 3030B (Gigahertz Solutions, Germany), the electric field varies enough that is comparable; however, the magnetic field has almost the same value. Therefore, we measured only the electric field in the experiment, instead of both electric and magnetic fields.

On average, the electric field in the exposure group was 320 V/m, whereas that in the non-exposure group was 10 V/m. At the same times (08:40, 14:00, and 20:30) each day, all pots were supplied with a maximum of 15 mL of water. Consistent with the growth pattern, to prevent the kidney bean plant stalks from falling, a stanchion (to which the plant is tied) is installed as shown in Figure 3.

Figure 3: A stanchion for supporting

III. Electromagnetic Field from the Electric Blanket

Among electrical appliances, the electric blanket is widely used, especially in winter. In this case, to reduce the EM field produced by the electric blanket, two methods are generally applied, although they do not completely eliminate the field. The first method is cancelling of the EM waves generated by the heater wire by twisting the heater wires. The second method is circulating water that is heated by a separate heating device. In this experiment, we used an electric blanket that uses twisted heater wires, as mentioned in the first method.

In the electric blanket with twisted heater wires, the magnetic field is attenuated to some degree; however, most of the EM field is not attenuated. Additionally, for temperature control, the phase control method is utilized, which produces an extremely high-frequency EM field. For the test electric blanket, the magnetic field has a significantly lower amplitude (by a factor of 10) than the EM wave. Therefore, for comparison, the EM waves, which are relatively unattenuated, are measured.

IV. Result and Discussion

Measurements were made at a point 12 cm from the temperature controller, where the EM wave usually occurs. All measurements were repeated at least three times. Data collection was performed three times per day (when watering the pot). The electric field was measured because the

magnetic field did not radiate significantly and has almost the same value regardless of distance.

A. Stem growth measurement criteria

When measuring the stem height, the criteria is that the starting point of the stem is the soil surface for each pot and the end of the stem is measured at the split-leaf section.

B. Leaf growth measurement criteria

The lengths of all leaves were recorded by measuring the length from the split-leaf section to the leaf tip. The mean value of the lengths of all leaves of a plant was considered for further analysis. The number of leaves increases as the plant grows over the course of the experiment, thereby reducing the average value. Therefore, the length of the leaf is measured from each layer in each population as an average value (a layer is the set of leaves that split from the same stem point and a layer number is assigned, counting from that closest to the roots).

C. Field measurement

a. Exposure case

The average field is roughly 360 V/m.

Figure 4: Field level in exposure case

b. Non-exposure case

The average of the field is roughly 8 V/m.

Figure 5: Field level in non-exposure case

D. Growth measurement

For measurement of the length of the leaf, the average value was considered after measurements of both exposure and non-exposure cases. The height of the stem also uses the average value for each population.

Figure 7 shows the average height of the stem in each population (as a growth index) versus the measurement date. Initially, the height of the stem is 15.4 cm ± 0.3 cm; in the experiments, the plants grow quickly. As a result, the height of the stem between exposure and non-exposure cases shows a relatively small difference.

Figure 6: Field level in the test laboratory

Figure 8 shows the average length of the leaves in each population as a growth index. Initially, the length of the leaves was 4.6 cm ± 1 cm. The graph shows two decreasing points, which indicates that the average value is reduced by including newly grown leaves. After growing to some extent, the length of the leaf has only a small difference (within 0.13 cm) at the end of the test. All of the data from Figure 7 and Figure 8 were average values for six different control groups.

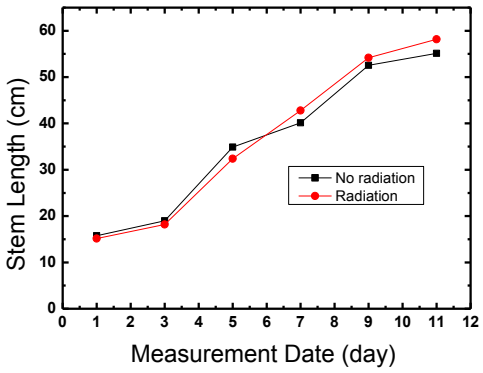


Figure 7: Growth of stem

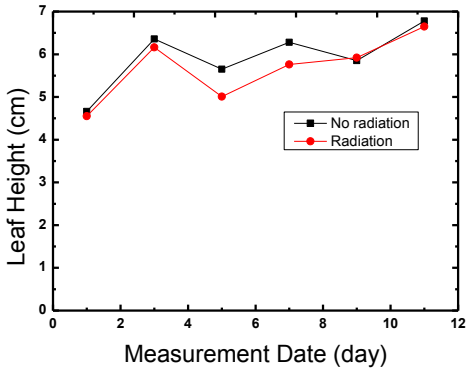


Figure 8: Growth of leaf [cm]

At the end of the test, the state of the leaves of the exposure group exhibits the withering phenomenon and the unexposed group shows good status, in terms of touch and the gloss of the leaves.

Figure 9: Non-exposure group

Figure 10: Exposure group

As a growth index, this paper uses the height of stems and lengths of leaves of kidney bean plants on test days; the results show that the EM field does not have a noticeable effect on the growth of kidney bean plants, as shown in Figure 9 and Figure 10.

V. Conclusion

We carried out experimental investigations of the impact of high-frequency, low-intensity EM fields on the morphometric growth parameters of kidney bean plants. From the results, the height of the stem and the length of leaves between exposure and non-exposure cases showed relatively small (i.e., not significant) differences. In other words, EM fields do not have a strong influence on the growth of kidney bean plants. Further research will be required to determine how to protect people from the adverse effects of EM waves.

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