The Effect of Electric Field on Bean Sprout Growing

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Abstract:
This paper presents the effect of electric field on the young vegetables growing. Bean sprout has been chosen because it growing rate is very fast and simple to implement. Growing between with and without electric field is presented. This research is focused on the height of stems and the length of roots. Numbers of seed in each plastic box, temperature and reactive humidity are controlled. The changing of bean sprouts are observed every day last for 5 days. The growth during the exposure is calculated by testing hypotheses about two population means. Experimental results indicate that the bean sprout in electric field has a better growth comparison to that of without electric field based on statistical analysis.

Keywords: Electric field, Bean sprout, EMI, Bio effect

1. Introduction

The effect of electric and magnetic fields on biological systems and human beings is a subject of considerable concern and investigation [1, 2]. In the last few years, some researchers show the effect of magnetic field with human body and biological tissues [3, 4]. However, the very few researches show the effect of electric field with plant growing. This paper has been proposed to present the effect of electric field on the bean sprouts growing. In this experiment, electric field is uniform field. Electric field intensity of 25 kV/m is used. An electric field is called uniform if its strength does not change with distance [5]. The electric field intensity is,

$$E = \frac{V}{dh^*} \quad \text{V/m} \tag{1}$$

Where d: the distance between the plates measured in meters.

h^*: field utilization factor as

$$h^* = \frac{E_{av}}{E_{\max}} \tag{2}$$

In this experiment, h^* is 0.8. Experimental result is considered by statistics principle.

2. Theory

Numbers of the sample are 100 seeds, then the statistic approach is involved. There are different criteria for determining the center, and so there are different definitions of measure of central tendency. It is involved comparing the performance of two or more groups.

2.1 Central tendency

A measure of central tendency is value at the center or middle of a data set [6]. It is the single value that best describes the performance of the group.

2.2 Mean

The arithmetic mean of a set of scores is the value obtained by adding the scores and dividing the total by the number of scores [6]. The symbol used to represent the mean is $\overline{X}$. The formula for the mean is,

$$\overline{X} = \frac{\sum_{i=1}^{N} X_i}{N} \tag{3}$$

2.3 Variance and standard deviation

The most commonly used measures of variability are the variance and standard deviation. The variance is the arithmetic average of the sum of squared deviations about the mean. The standard deviation is defined as the positive square root of the variance [7]. Both of these measures are always positive and both are calculated using squared deviations about the mean. The deviation score formula for the variance of a set of X scores is,

$$S_x^2 = \frac{\sum (X_i - \overline{X})^2}{N} \tag{4}$$

The deviation score formula for the standard deviation of a set of X scores is,

$$S_x = \sqrt{\frac{\sum (X_i - \overline{X})^2}{N}} \tag{5}$$

2.4 Inferences about two means: Independent and large samples.

The testing hypotheses about two population means and constructing confidence intervals for the

difference between two population means are focused. The following assumptions for the methods are used as follows:

1. The two samples are independent,
2. The two samples sizes are large. That is, $n_1>30$ and $n_2>30$ [6].

The formula for test statistic for two means is,

$$Z = \frac{(\overline{X}_1 - \overline{X}_2) - (m_1 - m_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \qquad (6)$$

Where m_1 is arithmetic mean of bean sprout with electric field.

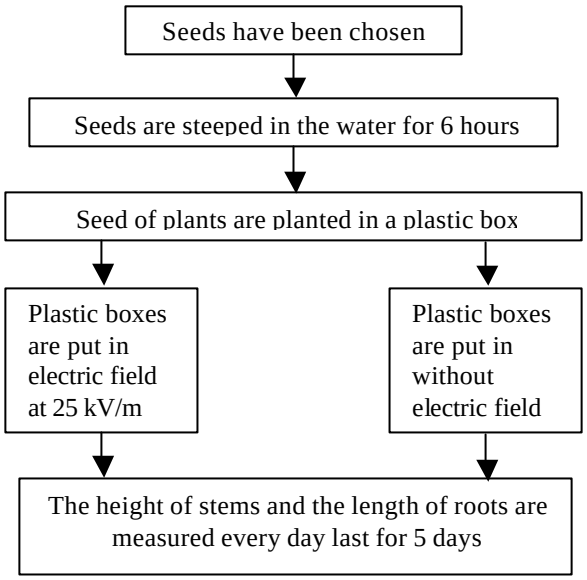
m_2 is arithmetic mean of bean sprout without electric field.

S_1 is standard deviation of bean sprout with electric field.

S_2 is standard deviation of bean sprout without electric field.

Z is normal distribution value.

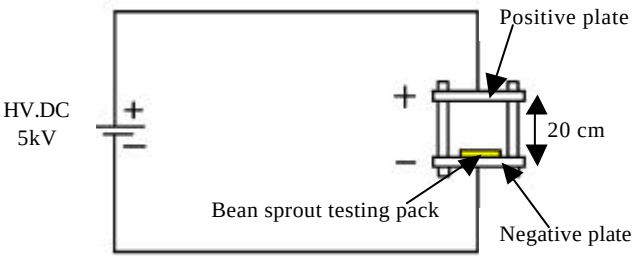
3. Experimental Setup



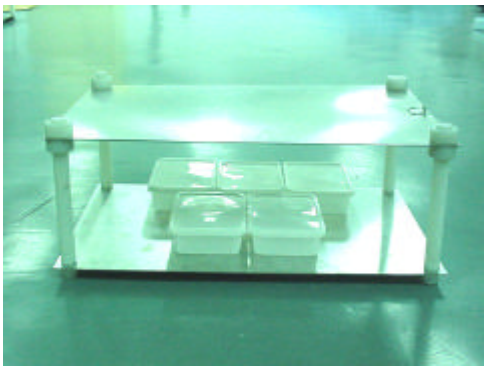
Note: Temperature and reactive humidity are controlled.

Figure 1 Flowchart of the experimental setup

Bean sprout has been chosen for this research because it growing rate is very fast and simple to implement. Seed of bean sprouts are planted in a plastic box at the room temperature. Five implemental boxes are used. There are 20 seeds in each box. The total numbers of seed are 100. Width of plastic box is 11.5 cm and length is 18 cm. Special tissue papers are used for that of plant growing where the amount of water is controlled. The comparison of the plants growing between with and without electric field is done. This research focused on two parameters of the growing for the height of stems and the length of roots. Temperature and reactive humidity are controlled at 28°C and 65 % respectively. 5 kV DC Voltage is applied to obtain electric field intensity of 25 kV/m. The diagram of experiment shows in fig. 2.



(a)



(b)

Figure 2 (a) Diagram of the experiment
(b) Aluminum high voltage plate

The distance between the plates is 20 cm. The growing of bean sprouts is observed every day last for 5 days.

4. Experimental Results

Analysis conditions of the collected data are as follows:

1. The significance level is 0.05,
2. Null hypothesis is H_o: $m_1 \leq m_2$,
3. Alternative hypothesis is H_1: $m_1 > m_2$

This experiment is analyzed by testing hypotheses of two population means and constructing confidence intervals for the difference between two population means.

The test statistic, critical value and critical region are shown in fig. 3.

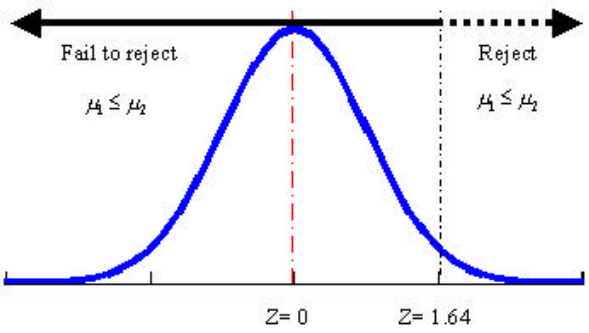


Figure 3 Critical value and critical region

Table 1 Mean, standard deviation and Z-value of the height of stem and the length of root.

	Mean		S.D		Z-value
	With E field	Without E field	With E field	Without E field	
Height of stem	36 mm	29 mm	25	25	1.98
Length of root.	41 mm	31 mm	23	16	3.57

Note: The mean, standard deviation and Z-value are the average value for day 1 to day 5.

Table 1 shows the arithmetic means of the height of stems and the length of roots with electric field are higher and longer than of those without electric field. Z-value indicates to support experimental results because z-value of the height of stems and the length of roots are more than 1.64. Then alternative hypothesis is accepted. For this reason, the arithmetic means of the height of stems and the length of roots of bean sprout with electric field are higher than of those without electric field. Those are equal to 24% and 33% respectively.

5. Analysis

Figs. 4 and 5 show the comparison of the height of stems and the length of roots between with and without electric field, which expose the bean sprout in with electric field is higher and longer than of those without electric field.

Fig. 6 shows the arithmetic means, maximum, and minimum of the height of stems from day 1 to day 5. The slope of arithmetic means of the height of stems for with and without electric field is increased during day 1 to day 5 that is raised gradually but it is maximum slope in day 4. During day 1 to day 5, the slope of arithmetic means of the height of stems for with electric field is higher than of that without electric field. Those are equal to 16.67%, 25%, 28.57%, 35% and 14.70% respectively.

Fig. 7 shows the arithmetic means, maximum, and minimum of the length of roots from day 1 to day 5. The slope of arithmetic means of the length of roots for with and without electric field is increased. During day 1 to day 5, the slope of arithmetic means of the length of roots for with electric field is higher than of that without electric field. Those are equal to 0%, 26.67%, 24.14%, 52.77% and 30.43% respectively.

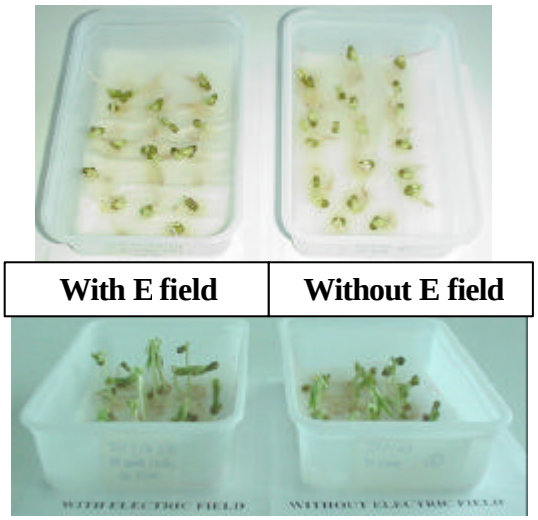


Figure 4 Comparison of the height of stems between with and without electric field. It is measured for 3 days after plant.

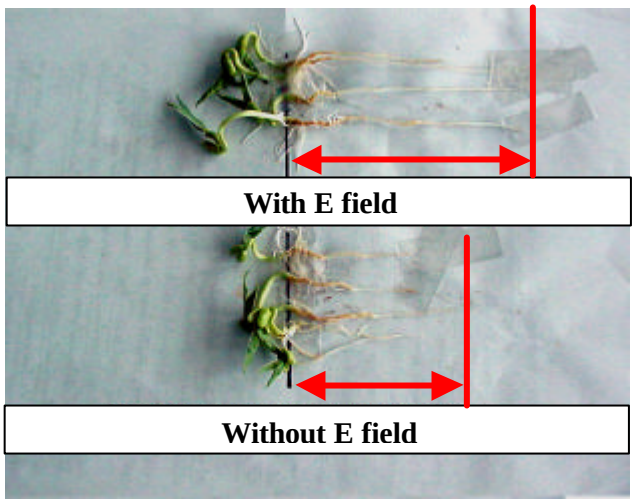


Figure 5 Comparison of the length of roots between with and without electric field. It is measured for 5 days after plant.

6. Conclusion

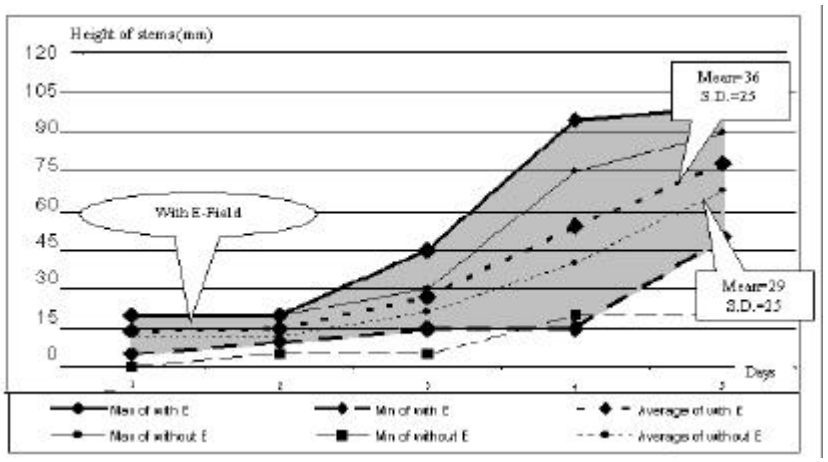
The effect of electric field on the growth of bean sprouts is presented. Electric field intensity at 25 kV/m is done. Temperature and reactive humidity are controlled at 28°C and 65% respectively. The height of stems and the length of roots have been considered in the experiment based on statistic approach. From these results, electric field influenced the height of stems and the length of roots. The height of stems and the length of roots in with electric field are higher and longer than of those without electric field. In further work, an effect of electric field intensity on the growth of bean sprout is investigated.

Table 2 Mean and standard deviation of the height of stems for each day

Day	With E-Field		Without E-Field	
	Mean (mm)	S.D	Mean (mm)	S.D
1	14	5	12	4.4
2	15	4.3	12	3.4
3	27	7.4	21	8.2
4	54	24	40	19
5	78	16	68	28

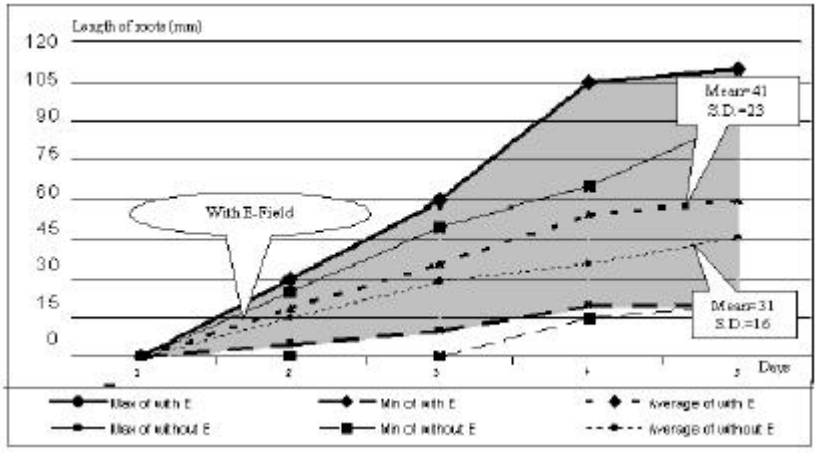
Table 3 Mean and standard deviation of the length of roots for each day

Day	With E-Field		Without E-Field	
	Mean (mm)	S.D	Mean (mm)	S.D
1	0	0	0	0
2	19	6.5	15	6
3	36	12	29	12
4	55	22	36	12
5	60	27	46	18



Note: The mean and standard deviation is calculated based on over 5 days.

Figure 6 Experimental results: the height of stems vs. days. Gray area is range of maximum and minimum for with electric field. The solid dash line shows the average for 5 days.



Note: The mean and standard deviation is calculated based on over 5 days.

Figure 7 Experimental results: the length of roots vs. days. . Gray area is range of maximum and minimum for with electric field. The solid dash line shows the average for 5 days.

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Prof. Dr. Shuichi Nitta earned BSEE and Ph.D. from Kyoto University and the University of Tokyo in 1960 and 1978, respectively. After working for the electric industry as a system engineer and quality assurance manager, he had been a professor of Tokyo University of Agriculture and Technology from 1985 to 2001. He retired the above university at the end of March 2001. Since April 2001, he is currently a professor of Salesian Polytechnic. His research interests are EMC maintainability and safety. Dr. Nitta is a member of IEEE, IEICE, IEEJ, SICEJ, REAJ and AFSMI.