The Study of Bending Effect on the Growth of the Primary Root of Rice Caused by Electric Field

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Abstract: *This paper presents the effect of electric field varied in the horizontal direction to the growing of rice seeds (Oryza sativa L.) on a primary root stage. The comparison is done under the condition with electric field at 28.5 kV/m varied electrode and without electric field. This work is focused on the bending of the root under with electric field varied in the horizontal direction and without E-field. The results with E-field and without E-field are compared. The majority direction of root is bended to negative electrode.*

1. Introduction

The effect of electric field to the growing of rice plants has been studied [1], [2] and in the past the studies about effect of magnetic field on the growth of plants, for example, on the germination of seeds of wheat and barley [3], on the growth of primary roots of corn [4], and the effect of the short time and partial application of the magnetic field on the growth direction of the plant root [5], have been reported. However, there had been on examples with electric field effect on the growth of the primary root. In this study the primary root of rice are experimented under the condition with electric field varied in the horizontal direction at 28.5 kV/m and without electric field, then investigated the effect on the growth of primary root. The results show direction of primary root dependence on the direction of electric field.

2. Applied E-field

The breakdown field strength E_b for aluminum plates is based on electrode configurations, dielectric properties, relative humidity, atmospheric pressure, temperature and etc. The employed electrode used in this germination makes dissimilar electric field strength in each point. The uniformity of electric field strength depends on a figure of electrode. Electric field strength [6] can be calculated by equation (1-3).

$$E_{max} = \frac{U}{d\,\eta^*} \qquad (1)$$

$$\eta^* = \frac{E_{av}}{E_{max}} \le 1 \qquad (2)$$

$$E_{av} = \frac{U}{d} \qquad (3)$$

U = *the voltage between electrodes* (V)

d = *the distance between electrodes* (m)

η^* = *the field utilization factor*

E_{max} = *the maximum of electric field stress* (V/m)

E_{av} = *the average value of electric field* (V/m)

The electric field is 28.5 kV/m beneath the 300 kV DC transmission line [7]. In order to realize the experimental condition equal to the practical condition (28.5 kV/m), it to be given by HVDC shown in Figure 1 is calculated from equation (1-3). η^* = 0.8 is used in this experiment.

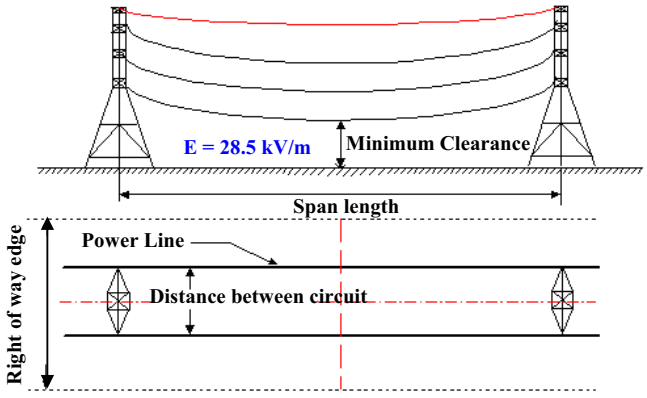


Figure 1 300 kV DC transmission line

In the 300 kV DC transmission line, the calculated voltage between electrodes is as follow :

$$E_{max} = \frac{U}{d\,\eta^*}$$

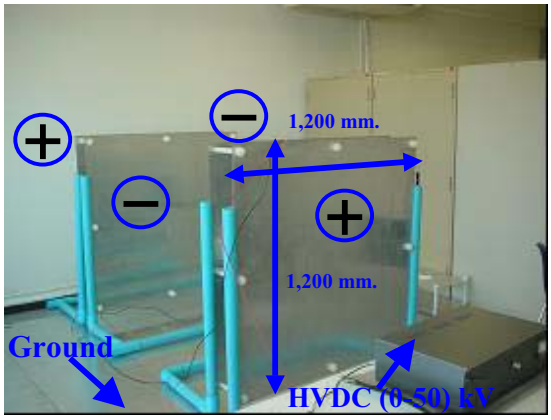
$$28.5\times10^{3} = \frac{U}{20\times10^{-2}\times0.8}$$

$$U = 4,560 \quad \text{volt}$$

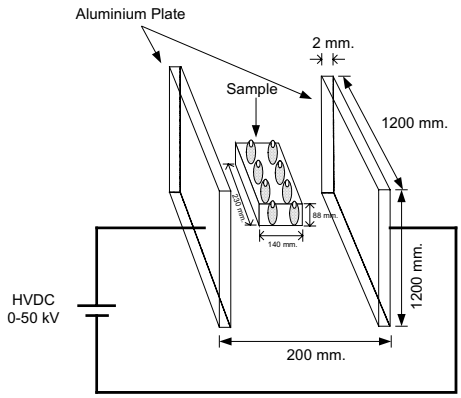
3. Experiments and Measurements

3.1 Experimental Apparatus

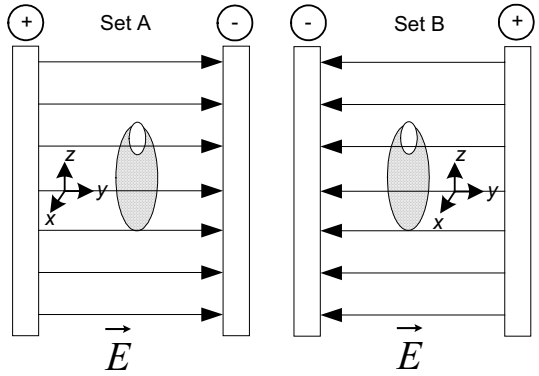
This research is carried out using HVDC power supply generating level 0-50 kV with current 3 mA at 10% ripple factor. Two aluminum plates are used as the positive and negative electrodes. The polarity can be selected both of positive-ground and negative-ground. The distance from the bottom plate to the top plate is equal to 200 mm. Each plate is isolated by PVC bolt. Figures 2 and 3 show the HVDC power supply, the HVDC electrodes, the test system and the experiment procedure, respectively.



(a) General view



(b) Block diagram



(c) Block diagram of electric field direction

Figure 2 Test system

The effect of Electric field to the growth of primary root of rice has been studied by comparing between 2 conditions. These conditions are as follows.

1. Rice is growing under E = 28.5 kV/m varied in the horizontal direction at 1 day.

The polarities of aluminum plates are used as follows:

1.1 the positive-negative electrodes. (Set A)
1.2 the negative-positive electrodes. (Set B)

2. In reference box, rice is growing without electric field.

Rice is laid vertically.

E = 28.5 kV/m is set up by referring to the practical power line transmission 300 kV in Thailand, where the V_{dc} = 4.56 kV and the transmission line height = 8.5 m.

3.2 Measurements

The experiment is carried out as shown in Figure 3.

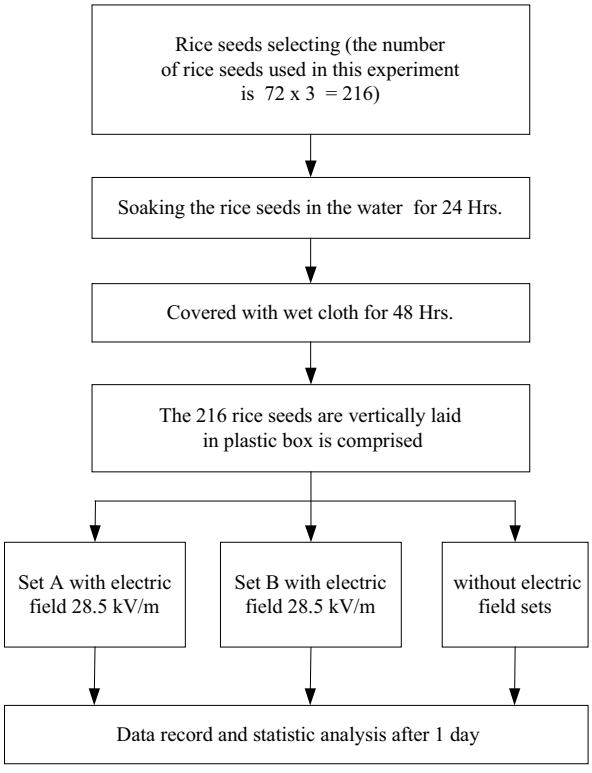


Figure 3 Experiment procedure

A. Procedure of the experiment

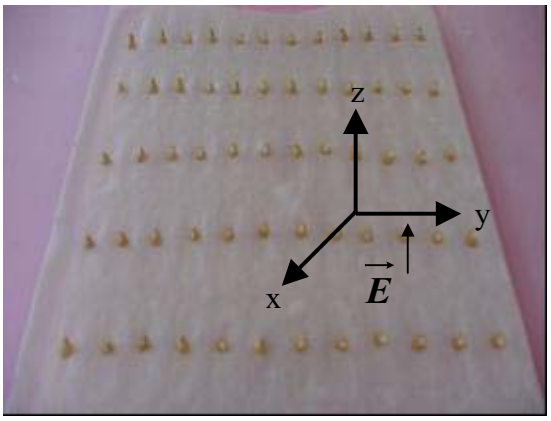
The rice seeds (Thai rice type named Suphan Buri type 1) with the same size and weight are selected and soaked in the water for 24 hours. Then, the rice seeds are covered with wet cloth for 48 hours. 72 seeds are placed in each plastic box, which these boxes have their cover as shown in Figure 4. In the experiment, two special paper sheets are used on the base in boxes and the 20 ml of water filled into

plastic boxes are arranged. The rice seeds under test in plastic box are placed between the two aluminum plates which the distance from the bottom plate to the top plate is equal to 200 mm. The aluminum plates have separated into 2 groups, the first group is the positive and negative electrodes. The second group is the negative and positive electrodes. The room temperature and relative humidity are equal to 25 ± 2 °C and 70 %, respectively.

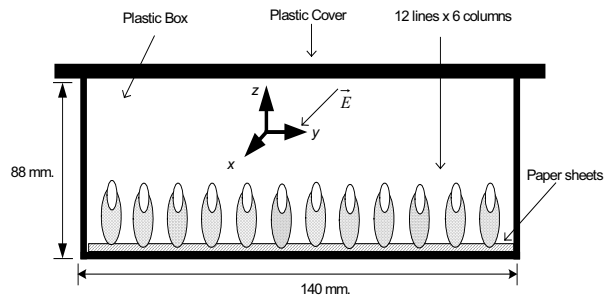
The 72 rice seeds of 216 are laid under the condition of without electric field for 1 day. 144 rice seeds are separated to 2 groups of 72 rice seeds. Each group is exposed to the 28.5 kV/m electric field for 1 day. The test has been done based on statistic data.[8]

Rice seeds containing in 3 plastic boxes are used for each condition. The growing of these plants are recorded by the measurement of their the length of their roots and the space angle of the root direction after 1 day exposure to electric field. The experiment is carried out following the diagram in Figure 3.

Figure 4 shows the layout of rice seeds.



(a) Layout of sample rice seeds (Photo)

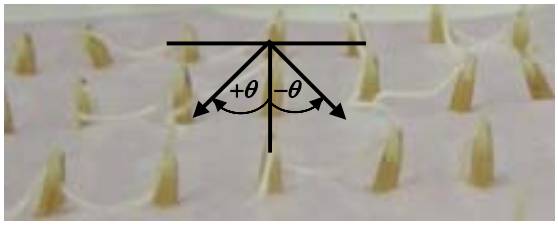


(b) Vertical Set

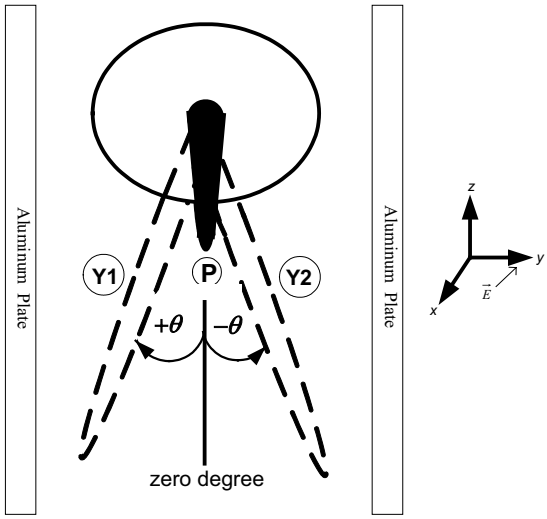
Figure 4 Layout of rice seeds

B. The measurement of the growth of a primary root

The measurement of growth of a primary root, measured the space angle of the root bending location after the exposure to electric field at 1 days. From these values calculated the average of angle of the growth direction of root bending.



(a) Layout of measured angle definition (Photo)



(b) Angle definition (Top view)

Figure 5 Rice seed with a primary root and definition of the axes
- Solid line shows the root direction before exposuring to electric field.
- Dash line shows the root direction after 1 day exposuring to electric field.

Figure 5 shows rice seed with primary root and the measured angle definition. The solid line means the root before exposuring to electric field while the dash line means after exposuring. There are two measurement points at near middle of length of roots *Y1* and *Y2* in an experiment: *Y1*,*Y2,* the point corresponding to point *P* after exposuring.

This experiment defined the angle of a root before and after exposure as the angle from *P* to *Y1*, $+\theta$, and from *P* to *Y2*, $-\theta$, respectively. Where *X, Y,* and *Z* are the directions shown in Figure 4. The direction of the gravitation coincides with *-Z* . Line of electric force runs parallel with Y axis.

4. Experimental Results

Figure 6 shows the averaged values angle direction of primary roots was examined.

1. In condition as the positive and negative electrodes (Set A). The direction of primary root measured as angle (θ) has positive angle more than negative angle. It shows that the position of primary root was bending to the negative polarity higher than positive polarity.

2. In condition as the negative and positive electrodes (Set B). The direction of primary root measured as angle (θ) has negative angle more than of those positive angle. It shows that the position of primary root was bending to the negative polarity higher than positive polarity.

3. In condition without electric field. The direction of primary root measured as angle (θ) has positive angle more than negative angle. But the average angle direction of the growth of primary roots have small values to positive angle because the angle is distribute.

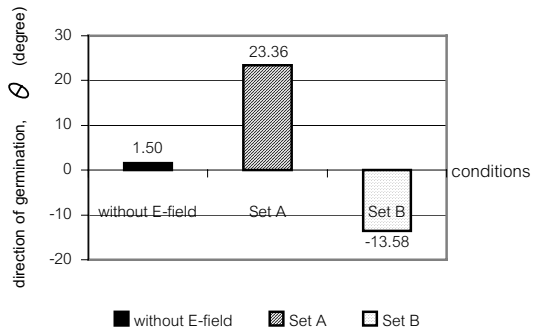


Figure 6 Averaged values angle direction of the growth of primary roots *(Set A; the positive- negative electrodes and Set B; the negative- positive electrodes)*

Note : For example 23.36 is measured from summation of total angle divided by number of seeds.

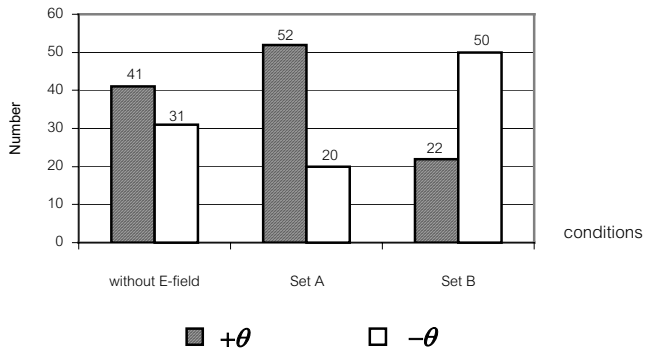


Figure 7 Number of direction of the growth of primary roots *(Set A; the positive- negative electrodes and Set B; the negative- positive electrodes)*

Figure 7 shows the direction number of the growth of primary roots. It shows that in condition with electric field as set A has number of positive angle more than negative angle and set B has number of negative angle more than positive angle. However in condition without electric field has number of positive angle and negative angle is nearly the same.

5. Conclusions

Rice is growth with electric field 28.5 kV/m at 1 day varied electrode (Set A and Set B) is observed the angle of primary root. From the result, the arithmetical mean of angle direction of the root are shown that the growth of primary root with electric field bending toward the negative polarity, which dependence of the direction of electric field. It is confirmed by the average of angle and number of the direction. In condition without electric field, it shows that the bending of primary root toward both positive and negative polarity is quite neutral.

References

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