Effect Of Electric Field In The Soil On The Germination And Growth Rate Of Rosecoco Beans Plant

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ABSTRACT

This study shows the effect of electric field on the germination and growth of bean plants. Rose coco beans was chosen because its growing rate is fast and it's a common food plant. An electric field was applied in the soil and is expressed in terms of electric energy density created within pairs of copper plates with different polarities (-ve and +ve) forming electric impulse with 9V DC current at room conditions for 6 hours a day. A control sample was treated similarly except with no electric field applied. The growth parameters investigated were the germination rate and the heights of the stems and were recorded after every 4 days. The obtained results shows a positive effect on the germination of about 27.8% positive deviation and improved height gain rate of 32.1%. This data shows that electric field could have an effect of awakening seed dormancy which result to faster germination, and positively influence other biochemical processes resulting to higher growth rates.

Keywords: Rose-coco beans, electric field, germination rate and growth rate

1. INTRODUCTION

The major effects of electric and magnetic fields on plants and human beings has been a subject matter of consideration and concern in the last few years [1,2]. The first attempt to unlock the power of electric current to plant germination, as mentioned by Wheaton, 1968 [3] was done by Maim bray of Edinburg in 1746. Research first narrowed on the effects of magnetic field to human body and plants but later on showed the effect of electric current with plants which has claim that electricity can improve the growth of plant if all other factors like water and sunlight are kept constant.

Early Research on Effects of Electric Field to Plants has shown that Low frequency electromagnetic fields (EMF) produced as a result of the Earth's environment originate from various sources: geomagnetic fields in the atmosphere and cosmic radiation [4]. All living organisms, including plants, have been exposed to the Earth's natural EMF from the beginning of life. They have adapted to it, over 2 – 3 billion years of their evolution. Numerous studies show an association of the internal EMF of plants with many physiological processes. For example, the electric current is involved in graviperception [5] and root growth [6]. Plants use their internal EMF for determining and controlling their biochemical components [7] specifically, for setting their biological rhythms [8]. A study concluded that continuous of exposure of plants to electric field of nominal magnitudes much greater than the terrestrial field is not beneficial [9], however, others tudies conceded that exposure of plants to lower intensity of short –time pulse of electric field might be beneficial as opposed to high electric fields since this will stimulate enzymes [10].

Effects of electric field with respect to different plants has been studied and shown to vary depending on plant species [3]. For example, it was demonstrated that when electric field is applied in the soil in tomatoes it growth rate is accelerated [11], rice seed subjected to electric field have high growth rate at about 15% but electric field

has no effect on its germination rate [12,13]. Apart from rice seed, lettuce seed germination rate increases sharply when exposed to 7.5V/cm of electric field [14], cotton plant showed positive result when exposed to a 3.5Kv/cm field. However, when the electric field is beyond 3.5Kv/cm its germination rate and growth rate are completely sterilized. For grain bearing plants, the stem height increases by 24% and the length of the root increases by 33% when an electric field intensity of 25Kv/m was applied [3].

For leaving cells to survive, they need electrical activities in their tissue cells which leads to their change in behavior in the pollen grains, buds and even in their roots, this change of behavior comes about when their molecular and biochemical components in the tissues are positively stimulated by electric fields applied to the plants which then excites the enzymes that are responsible for the plants growth and development especially in leguminous plants(Simply Leguminous plants are those which belongs to the Pea family Leguminosae [15]. This theory was demonstrated in Wisconsin fast plants, which germinates within 1-2 days [16]. The study concluded that electric field may stimulate the metabolic process in plant cells and tissues. In living organisms, their molecule structure and changes thereof, e.g. the pattern of cell divisions and hence growth are dominated by biochemical processes which were shown to be disturbed even by a weak electric field [17]. These biochemical processes are the ones which accelerate the growth of living organism due to the interaction amongst their electrically charged components and therefore it is suggested that the growth of a plant is sensitively reactive to external influence exerted by the electric field in the soil thus based on the statistics analysis done in by [18, 19], it is clear that electric field had a better growth when compared to that without electric current.

Being that rose coco beans is a leguminous plants and therefore expected to have its physiology affected by E-fields. In the world of today, food security has become a major threat to many nations therefore; efforts are required to improve food security. One way of doing this is to fasten the growth rate and germination rate of vegetables hence faster productivity in automated farms. The existing research has not exhausted on the effects of electric field on leguminous plants in the soil especially beans plant hence the need for this study. The objective of this research was to determine the germination rate of rose cocoa beans plant and its germination rate when electric field was applied to it in the soil.

2. MATERIALS AND METHODS

Seeds were immersed in water for 6hr before the start of the experiment, The independent variables was the amount of electric stimulation given to the plant. The dependent variable is the height of the beans plant, this was done by measuring the height of the 10 plants in each group and calculating their average height, the constants were the amount of water used, the amount of sunlight received and the type of plant used (beans plant). Two pots were then labeled A and B and the same amount of soil filled in both pots, nine beans seeds was then planted in each pot and the seed was then buried deep in the soil at similar depths. The beans seed

planted in the soil in the two pots was to be 20mm apart from each seed planted after which two copper plates was then planted in the soil of the pot labeled A. The copper plates were placed at opposite sides of the pot at vertical arrangement but parallel to each other.

The D.C 9V battery was then connected to the copper plates for 6hrs every day for the next twenty days whereas both Pots were provided with the same amount of water (100ml) twice a day both in the morning and in the evening and also both pots were placed in a location with equal provision of sunlight. The height of the plant was measured after every 4 days and their average height calculated and recorded in the result table. This experiment is carried out in the laboratory at room temperature when all other factors are kept constant.

The field strengths in the electric field depends on the dielectric between the two plates and the electrodes in which the electric field is applied, this is because dielectric materials usually contains minute defects thus only a fraction of the electric field will be of use [20]. Electrical properties in the soil can be divided into two that is the chemical properties and the physical properties. Soil chemical properties are the soil minerals and soluble salts in the soil while the soil physical properties are the water content and temperatures influencing the mobility of electrical charges in the soil [21] , the presence of water in the soil particles is what increases the electrical conductivity thus forming the electric field within the soil [22].

3. RESULTS AND DISCUSSION

3.1 GERMINATION RATES AFFECTED BY ELECTRIC FIELD

The data from this study shows that germination rates were affected by the presence of electric field in the soil as shown in Figure 1. The plotted data is an average of three independent experiments.

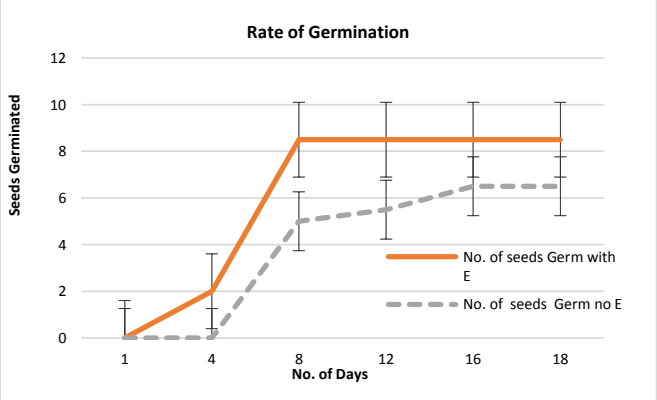

Figure 1: Rate of germination of rose coco beans seeds treated with an electric field of 105.88 V/m , (solid line) compared with control experimental seeds with no electric field (dashed line)

At day 8 and 12, the standard error bars are not overlapping showing the data has some significant difference. Total number of germinated seed with electric field was 72, against the total number of planted seeds, 90,

which gives 80 % germination rate after 18 days. This is contrasted with a 52.2% germination rate for the samples without electric field for the same number of days. The two shows a 27.8% positive deviation.

3.2 GROWTH RATES AFFECTED BY ELECTRIC FIELD

This experiment was repeated three times and the independent experiments, the raw data tables are shown in the appendix and analyzed data in graphs are shown in Figures 2, 3 and 4. The mean of the three is shown in figure 5. The data shows that the growth heights of beans plant in sample (blue curve) with electric field was faster than the control sample (red curve) with no electric field supplied. In the first experiment represented in figure 2, that was run the mean height for the rosecoco beans grown with an applied e-filed was 34.5 cm, and that without electric field had a mean height of 25.4 cm. This is a difference of mean height of 9.1 cm, or 35.8 % increase in height gain at day 20 of the experiment.

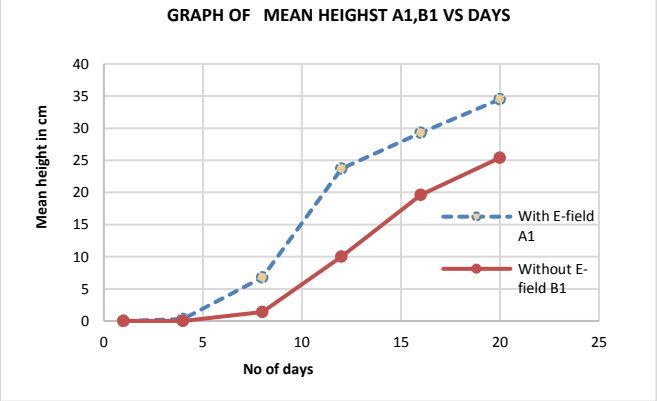

Figure 2: A graph of mean heights of beans grown with electric field in the soil (dashed line) and Without the electric field (solid line) verses number of days for experiment I

In the second experiment represented in figure 3, that was run the mean height for the rosecoco beans grown with an applied e-filed was 36.4 cm, and that without electric field had a mean height of 22.8 cm. This is a difference of mean height of 13.6 cm, or 59.64 % increase in height gain at day 20 of the experiment.

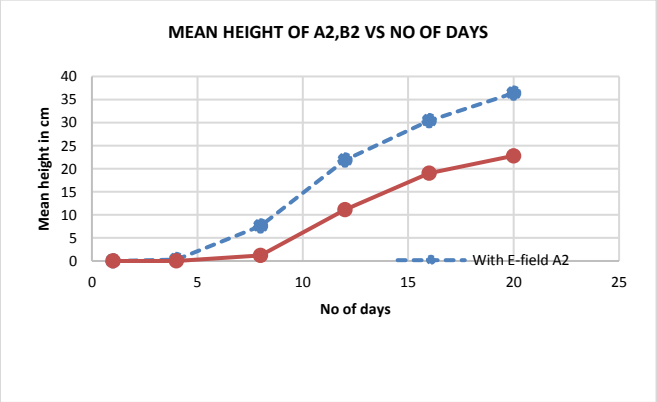

Figure 3: A graph of mean heights of beans grown with electric field in the soil (dashed line) and without the electric field (solid line) verses number of days for experiment II

In the third experiment represented in figure 4, that was run the mean height for the rosecoco beans grown with an applied e-filed was 35.5 cm, and that without electric field had a mean height of 24.1 cm. This is a difference of mean height of 11.4 cm, or 47.3 % increase in height gain at day 20 of the experiment.

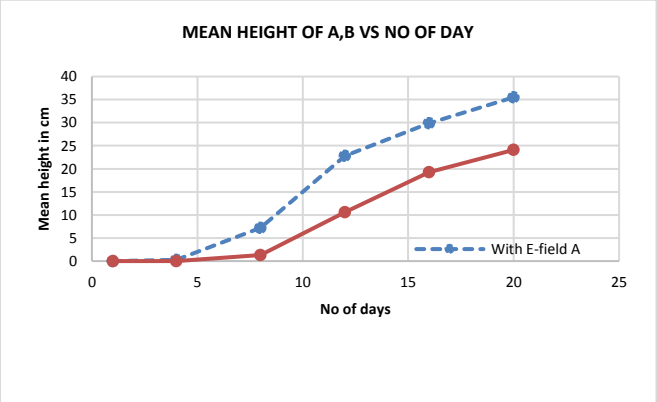

Figure 4: A graph of mean heights of beans grown with electric field in the soil (dashed line) and without the electric field (solid line) verses number of days for experiment III

Figure 5 shows the average of the above three experiments. The las recordings on 20th day shows that the mean height of rosecoco beans grown with an applied e-filed was 35.5 cm, and that without electric field had a mean height of 24.1 cm. This is a difference of mean height of 11.4 cm, or 47.30 % increase in height gain. The data form the graphs and the photos shown in figure 8 shows that there was faster growth rate in A which is the treated sample with electric field than B which is the control sample without electric field. The plates in Figure 6 shows images captured in the course of the experiments after germination.

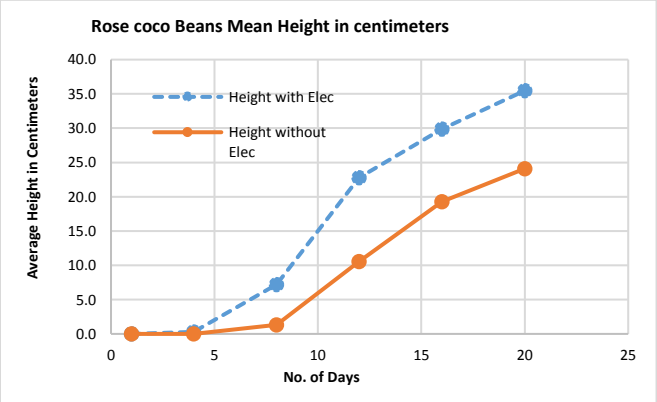

Figure 5: A graph of mean heights for the three experiments I,II and III of rose coco beans grown with electric field in the soil (dashed line) and without the electric field (solid line) verses number of days

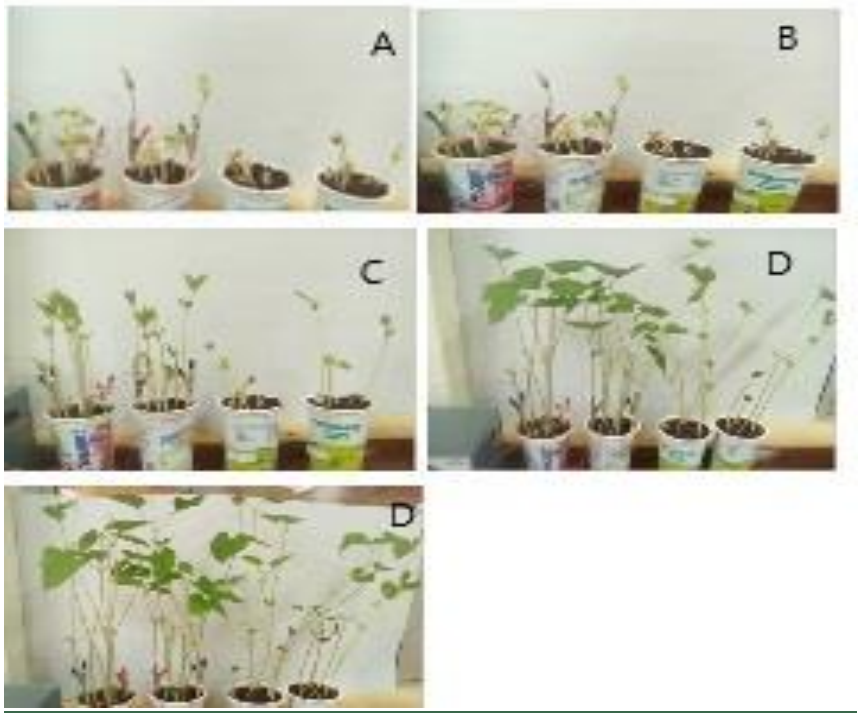

Figure 6: Plates of rose coco beans growing, taken during the research period on both treated sample with electric field (the two on the left of each plate) and control sample without electric field (the two on the right of each plate).

The key objective of this study was to determine the rate of germination of rosecoco beans and to determine the growth rate. The data obtained from the research clearly shows that the germination rate of the controlled sample in pot B was slower than the rate in the treated sample in pot A. the rate of germination in control sample B was 75% after the twelfth day whereas in the treated sample A the germination rate was 75% after a duration of the eighth day. A positive percentage deviation of 32.11% was obtained; this showed that the treated sample of pot A had a positive deviation of mean height of 11.4cm compared to controlled sample pot B. This variation in the rate of germination must have been due to the effect of electric field applied in pot sample A since the interaction of electric field to the biochemical components of beans seed excites the activities of hormones responsible for growth in plants thus weakens the seed dormancy. Fastest rate of growth of rosecoco beans was observed between 12^{th} and 16^{th} day when an electric field supplied to the treated sample that is A was 105.88V/m in an area of $5.67523\times10^{-5}m^2$ this could have been as a result of the active enzymes catalase responsible for breakdown of biochemical and molecular components of the plants had their working PH enhanced thus performing their best in exciting the growth hormones in xylem and phloem leading to faster growth rate resulting to a high positive deviation compared to controlled sample B.

Of all the samples under experiment both treated sample with electric field A and control sample without electric field B no group recorded a 100% growth turn out on the 4^{th} day despite carrying this research at room temperature and laboratory conditions, luckily enough, the treated sample had showed some signs of

germination on the 4th day though the turnout was insignificant, However the pot labeled A2 recorded a 100% germination turn out on the 8th day.

Even though on the 16th day and 20th day there was some few beans identified in pot B that was taller than those in pot A, This is because the treated sample in both pots A1 and A2 almost all the seeds germination with pot A2 indicated a 100% turn out in germination on the 8th day. However sample B1 and B2 which was the controlled sample with no electric fields resulted to low turnout in germination as compared to treated sample with electric field in A1 and A2 respectively since all samples were filled with the same quantity of soil carrying same nutrients, these nutrients were being shared equally among the plants that had germinated in sample A1 and A2 that was 17/18 seed that had germinated while in B1 and B2 there was no competition of resources in the soil due to few beans that had germinated on the controlled sample that was 13/18 seeds that had germinated therefore sufficient nutrients for the few plants.

4. CONCLUSION

From the experimental research done on the effect of electric field on rosecoco beans plant, the result obtained indicated that even though there is no much relationship between physics and biology that is plants and electricity. There are some properties in plants that can be affected by the presence of electricity when placed near them. This research clearly indicates that electric field supplied to a plant within its roots can stimulate the growth of plants especially rosecoco beans plant that was under investigation. However we know that electricity can be dangerous at sometimes especially when it is too much and therefore for this research to be successful a number of factors was taken into consideration. The electric field calculated as per the result analysis indicated that for a nine bean s plant planted at an area of $5.67\times10^{-5}m^2$.only 105.88V/m electric field was to be supplied with a voltage supply of 9V for 6 hrs. a day this is because being that these were small young plants, too much of the voltage supply would have burnt them down.

Comparing the treated sample with electric field A and control sample without electric field B in the experiment, it was clear that there was high growth rate in sample A than in sample B. NOT only that , it was also observed that almost all the beans planted in sample A with electric field had germinated at the end beginning of the 8th day while the control sample B was still ongoing with its germination. Still in germination rate, the beans plant in A had showed some appearance of germination on the 3th day of plantation while in pot B there was no trace at all. This research now unveils the potential effect of electric field in the interaction of plants to their biochemical components that then enhance the growth rate of beans plant.

Being that this research was done on a laboratory I would like to recommend that same research be done on the open field so as to compare the result and findings. It is of my humble request that researchers take their time to dig deep on this area since its application and implementation may end the suffering of food scarcity being

witnessed in most counties thus a stable economy may be achieved as a result Also that this research was done when the DC power supply was at 9V for 6hrs a day, I would urge the scientist and researchers to look upon carrying out this research and supplying a voltage 9V all the time, 18V for 6hrs a day and 4V for 6hrs a day. This will help come up with a good systematic way on deciding which method of voltage application works best for faster growth of rosecoco beans or it could be that these could help get rid of some unwanted weeds in a beans plant plantation.

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5. REFERENCES

[1] M. Blank. Biological effects of environmental electromagnetic fields: molecular mechanism. BioSystems. 35:175–178. 1995.

[2] P. Rajendra, H.N. Sujatha, Devendranath D. B. Gunasekaran, R.B. Sashidhar, C. Subramanyam C. Biological effects of power frequency magnetic fields: neurochemical and toxicological changes in developing chick embryos. BioMagnetic Research and Technology. 2,1, 2004.

[3] F. W. Wheaton. Effects of various electrical fields on seed germination. Retrospective Theses and Dissertations. 3521. http://lib.dr.iastate.edu/rtd/3521. 1968.

[4] R. Feynman , R. Leyton, M. Sands. Feynmana wykłady z fizyki. Vol. 2. Warszawa: PWN; 2001.

[5] D.A. Collings, R.G. White, R.L. Overall. Ionic current changes associated with the gravity-induced bending response in roots of *Zea mays* L. Plant Physiology. 100:1417–1426. 1992

[6] M. Souda, K. Toko, K. Hayashi, S. Ezaki, T. Fujiyoshi, K. Yamafuji. Relationship between growth and electric oscillations in bean roots. Plant Physiology. 93, 532–536,1990.

[7] L.F. Jaffe, R. Nucitelli Electrical controls of development. Annual Review of Biophysics and Bioengineering. 6:445–476. 1977.

[8] I.A. Carre. Biological timing in plants. Cell and Developmental Biology. 7:775–780. 1996.

[9] L.E. Murr,. Plant physiology in simulated geoelectric and geomagnetic fields. Advancing Frontiers of Plant Science 15: 97-120. 1966.

[10] P. Barman, R. Bhattacharya. Impact of electric and magnetic field exposure on young plants, a review. International journal of current research and academic review, 4, 182-192.2016.

[11] J.D. Moon, H.S. Chung. Acceleration of germination of tomato seed by applying AC Electric field and magnetic field .journal of Electrostatics, 48; 103-114, 2002

[12] P. Kerdonfag, C. Kinsaard, W. Khanngern and Ketkaew. Effect of electric field from the electric field Rice grain separation unit on growth stages of the rice plant. Faculty of engineering and EMC laboratory.**5**: 250-253. 2002

[13] M. Carbonell, V. Martinez, J.M Amaya. Stimulation of germination in rice by a static magnetic field. Electro and magneto biology, 19, 1; 121-128, 2002.

[14] L. Stefa, A. Pozeliene (2003): Effect of Electrical Field on Barley Seed Germination Stimulation. Agricultural Engineering International **2**: 3-7.

[15] S.I. Aksyonov, A. Grunin, T.Y. Goryachev, V.B. Turovetsky. Physiochemical mechanisms of efficiency of treatment by weak ELFEMF of wheat seeds at different stages of germination. Proc 22nd Annual meeting Euro.Bioelctromagnetice Ass, Munich. 2000

[16] Jesca, Daniel, Emily, Justin. The effect of 8v electricity on the germination speed of Wisconsin plant, plant science research paper, (16) 2-3,2015.

[17] W. Wawrecki, B. Zagorska-Marek. Influence of a weak DC Electric field on root meristem architecture, Anals of botany (100), 791-796.2007.

[18] A.E. Bara'ah. Effect of electric current on growth and development of vicia faba L. science in botany, university of Khartoum,24-27. 2010

[19] G. Nechitailo, A. Gordeev. The use of an electric field in increasing the resistance of plants to the action of unfavorable space flight factors. Adv Space Res.; 34, 7:1562-5, 2004.

[20] Von, H.A.R. Dielectrics and waves. New York: Wiley. 1954.

[21] *A. Pozdnyakov*, L.*Pozdnyakova*. 17th WCSS, 14-21 August *2002*, Thailand. 1558-2.

[22] D.A. Robinson, S.B. Jones. Dielectric of materials and conductivity. Journal of geophysical research: solid earth. 108. 2003.