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**ElectroBloom: Using Mild Electrical Stimulation on
Demon's Pepper (*Capsicum chinense*)
to Enhance Early Growth**



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Proponents:

Gerardo P. Modio III
Kian I Tingcang
Andrei R. Cañete
Research Proponents

LIFE SCIENCE TEAM CATEGORY – Team Category

Consultants:

Eng. Drexand S. Perocho, MSE.
Qualified Scientist (Agricultural Engineer)
Isagani V. Cañete
Research Consultant
Eng. Jefferson G. Tingcang
Research Consultan
Henry F. Haranay
Research Adviser

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Gerardo P. Modio III
thirdymodio@gmail.com

Kian I. Tingcang
kian.tingcang@gmail.com

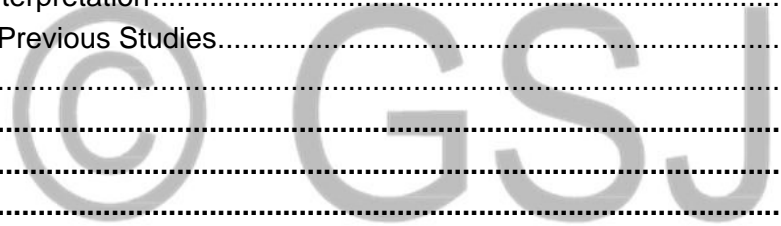
Andrei R. Canete
andreicanete53@gmail.com

ABSTRACT

*Elements of plant growth, such as electrical stimulation that could affect ion transport and hormone activity, have effects from various physiological and environmental perspectives. Chili plants have also unexplored the application of electroculture through an economical and environmentally friendly way. This study aimed to determine the effect of mild electrical stimulation on early growth performance on *Capsicum chinense* seedlings. The entire randomized treatment design (CRD) for the experiment consisted of three treatments (Control (0 V), Treatment 1 (3 V), and Treatment 2 (6 V)). For ten (10) days, mild direct current (DC) was provided through electrodes positioned in the soil, and daily measurements of plant height were conducted. According to the observed results, the average height of *Capsicum chinense* seedlings increased from 3.7 cm on Day 1 to 6.7 cm on Day 10, with uniform growth consistent in all treatments. Time significantly affected plant height ($p < 0.05$), but this effect was not significant with treatment ($p = 0.4997$), with two-way ANOVA. This suggests that while growth occurred organically in the experiment, there were no statistically significant differences from a 3 V and 6 V stimulation when compared to a control. By comparison, the mean growth rate ($6.4 \text{ cm} \pm 1.2$) was slightly higher in 3 V compared to 6 V in the 6 V treatment and control, suggesting that an increase in stimulatory effect was slight at low voltage. The plant health was normal throughout the evaluation and little electrical effects were found that stress and stunting was not observed. Combined with the findings of the study, this can be investigated as research into low voltage electroculture, a sustainable, affordable, and safe farm process.*

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1. INTRODUCTION

1A - Introduction

Agriculture is still one of the most important bases of global food production. The basic issues of limited land, unpredictable weather, and declining soil fertility are challenges still faced by farmers. In light of these constraints, the need arises to implement fresh, low-cost, and sustainable methods for enhancing the development and yield of plants. One such emerging method is electroculture, where mild electrical stimulation of a plant or soil is applied to speed up plant growth. The concept has received renewed scientific focus due to its simplicity, cost-effectiveness, and eco-friendly potential (ElectroCulture: Boosting Plant Growth with Electricity | Farms to Flowers, n.d.-b).

Low-voltage electrical currents have been reported to modify physiological and biochemical dynamics in plants, such as accelerated germination, enhanced root development, and enhancement of nutrient absorption. For instance, Li et al. (2019) showed that mild electrical stimulation in maize (*Zea mays L.*) improved seed germination and thermotolerance, and Lee and Oh (2020) observed better mineral uptake and antioxidant accumulation in kale (*Brassica oleracea var. acephala*). Similarly, Yi et al. (2012) demonstrated that low-voltage electric pulses in soil positively altered both plant growth and the microbial community, proving that controlled current can create a more favorable growing environment.

Demon's Pepper (*Capsicum chinense*), also known as siling demonyo in the Philippines, is a valuable crop with culinary and economic importance in the country. However, early growth tends to be slow and variable due to environmental and soil conditions. Mild electrical stimulation was applied, which may help improve its early performance by stimulating cell activity and nutrient mobility. According to Auxin Transport Theory, electric signals can affect the movement of auxin, the main plant hormone responsible for cell elongation and directional growth (Baluška, 2003).

This study adopts Ohm's Law of the relationship between current, voltage, and resistance to ensure safe and precise control of the applied current and to maintain an appropriate level of stimulation while not damaging plants or soil system. Based on the principles and results of Volkov (2007) and Scopa et al. (2009), the experiments are based on using simple and cost-effective materials (batteries, insulated wires, metal electrodes), under voltages of 3V, 6V, and 9V to impose direct current.

This is "ElectroBloom: Using Mild Electrical Stimulation on Demon's Pepper (*Capsicum chinense*) to "Enhance Early Growth" study as the objective is to find out how mild electrical Stimulation on Demon's Pepper (*Capsicum chinense*) affects the plant height and leaf development. By utilising a cheap, energy-efficient approach, the investigation aims at becoming a part of the expanding field of sustainable agricultural technology and by providing farmers a non-chemical, low-cost, and eco-friendly way to enhance crop productivity.

1B - Hypothesis

1. If demon pepper sprouts are exposed to mild direct electric current, then its growth rate and shoot length will increase compared to the seedlings without treatment.

2. REVIEW OF RELATED LITERATURE

2A - Electroculture

Electroculture is the use of electric fields or other sources of small air ions to stimulate growing plants. It has potential to markedly increase crop production and to hasten crop growth. Methods like antennas, direct current, and alternate current are used to improve plant growth. However, its effectiveness and studies of mechanics for its action is still being investigated (Christianto & Smarandache, 2021).

This unfamiliar method called electroculture is able to hasten growth rates, increase yields, and improve crop quality. It is also able to protect plants from insects and diseases which could be harmful to it. This method can lessen the need to use pesticides and fertilizer. Using this method farmers can easily produce bigger and better crops with less time and at a lower cost (Christianto & Smarandache, 2021).

During the research of Yi et al. (2012), it showed that using a low-voltage electric pulse charged to culture soil has positive results on the lettuce and hot pepper. The key results of his research are the following; the lettuce plants that were grown in soils with 4V to 10V stimulation had significantly greater biomass and leaf growth compared to the control group and the hot pepper which was also exposed to a similar treatment showed increased growth periods and higher fruit yield. He used a method that involves low-power, making it energy efficient and great for sustainable farming. This study shows evidence of the effectiveness of electroculture.

2B - Direct Current Stimulation on Plants

Direct stimulation on plants promotes growth, mineral uptake, and antioxidant accumulation. Several studies have shown that electric treatment has a positive effect on germination, root growth and post-harvest quality. Though, there is still a lacking number of evidence of electric treatment to the overall growth of plants (Lee & Oh, 2020).

A study by Li et al. (2019) showed that applying a low voltage current on maize (*Zea mays*) for 10 minutes significantly improves its seed germination and early seedling growth. The experimental group increased in shoot length as well as fresh weight compared to the control group. Furthermore, under heat stress conditions, the treated seedlings had better survival rates and tissue vitality. This study suggests that direct electric stimulation on maize not only improves growth but also may enhance resilience to environmental stress.

Another similar study conducted by Vashisth and Nagarajan (2009), investigated the effects of direct electric current on the germination and early seedling development of sunflower (*Helianthus annuus*) seeds. The seeds were exposed to a direct current electric field with varying amounts of volts per minute, from 100 to 250, for 10 minutes. The researchers found out that the seed treated with 200 V/m had significantly better germination rate, root length, and shoot length when compared to the control group. However, the one treated with 250 V/m showed decline in its growth perimeters, suggesting that surpassing the threshold can do more harm than good to the plant's growth. This study supports that a controlled, low-level direct electric current and optimizing its strength and duration can positively influence a plant.

3. Methodology

3A – Theoretical Foundation

The study is based on Ohm's Law and the Auxin Transport Theory. As the electrical source of the experiment, Ohm's Law ($V = IR$) guarantees controlling and keeping voltage applied to soil safe. This avoids too much current, which can hurt the seedlings, yet maintains stimulation at 3V and 6V.

The Auxin Transport Theory is the biological basis of how that happens (how electricity can be applied to plants). Electric signals can affect auxin (hormone that promotes cell elongation and directional growth in plants). When mild electrical stimulation is applied to plants, it enhances the movement of auxin within the plant tissues, promoting faster and healthier growth (Baluška, 2003). Cumulatively, these theories provide both physical and biological substrates for applying mild electrical stimulation in the early stages of *Capsicum chinense* growth.

3B – Experimental Design:

3B.1 Research Design

Research Design. A Completely Randomized Design (CRD) was used in the study, i.e., three treatments and six replications each. The treatments were:

- C (Control): No electrical stimulation.
- T1: 3 volts.
- T2: 6 volts.

Each treatment consisted of six cups of *Capsicum chinense* seedlings giving a total of 18 experimental units.

3B.2 Preparation of Materials

The materials used were:

Capsicum chinense seeds, sterilized soil, black grow bag, battery holders, AA batteries, insulated copper wires, alligator clips, galvanized nails as electrodes, digital multimeter, ruler, and timer.

2B.3 Seed Germination and Transplanting

The seeds of chinense were pre-germinated on a paper towel for 1 day. Uniform seedlings were transferred to black grow bags filled with 700 grams of sterilized soil after germination. Each seedling was dosed with 30 mL of distilled water daily and exposed to continuous sunlight.

3C – Electrical Stimulation Setup.

3C.1 Electrode Installation. Two 5-cm-long galvanized nails were placed in the soil on opposite sides of each cup while electrodes were introduced. The nails were inserted 2 cm from the seedling and 2 cm deep. About 3 cm of the nail was kept above the surface of the soil for the nail connection of wires. These nails were the positive and negative terminals of the electric current.

3C.2 Wiring and Voltage Source. The battery holders were prepared with the correct number of AA batteries to produce 3V (2 batteries) and 6V (4 batteries). The red wire (positive terminal) from the battery holder was connected to one electrode and the black wire (negative terminal) to the other, using alligator clips. An actual voltage across the electrodes was recorded on a multimeter to confirm the voltage before each stimulation session to ensure the desired voltage was achieved.

3C.3 Stimulation Procedure.

1. The setup was connected and voltage confirmed with a multimeter.
2. Electrical stimulation was applied once daily for 10 minutes.
3. After 10 minutes, the circuit was disconnected by removing one clip to stop the current flow.
4. This procedure was repeated daily for 10 consecutive days under consistent environmental conditions. The treatment of all plants was subjected to the same light, water, and temperature in each case to permit fair comparisons among treatments.

3D – Data Gathering Procedure:

3D.1 Growth Measurement. Assessment of the early growth performance of *Capsicum chinense* was done by the following measurements:

- Height of plant (cm): from the stem base to leaf tip. Daily (Day 1–10) measurements. Qualitative observations such as color, the texture of leaves, and any visible stress were observed as well.

3D.2 Documentation. All data were recorded in a growth log sheet, and photographs were taken at each observation to indicate visible differences between treatments.

3E – Statistical Analysis.

After collection of data, the data were analyzed using Analysis of Variance (ANOVA) for significant differences among several treatments. If there was a significant difference, Tukey's Post Hoc Test was performed to find out which treatments differed significantly. Results were reported by the mean \pm standard deviation. Bar graphs with error bars were employed to visually represent treatment differences.

3F – Experimental Safety and Cost Efficiency.

All stimulations were supported by battery-based DC sources to maintain electrical safety. There was no reliance on household current and no connection. Cheap and readily accessible, the parts (batteries, wires, and nails) made for a low-budget, environmentally friendly setup. This method shows that mild electrical stimulation may be applied with basic equipment safely and effectively, which may be suitable for small-scale and sustainable agriculture.

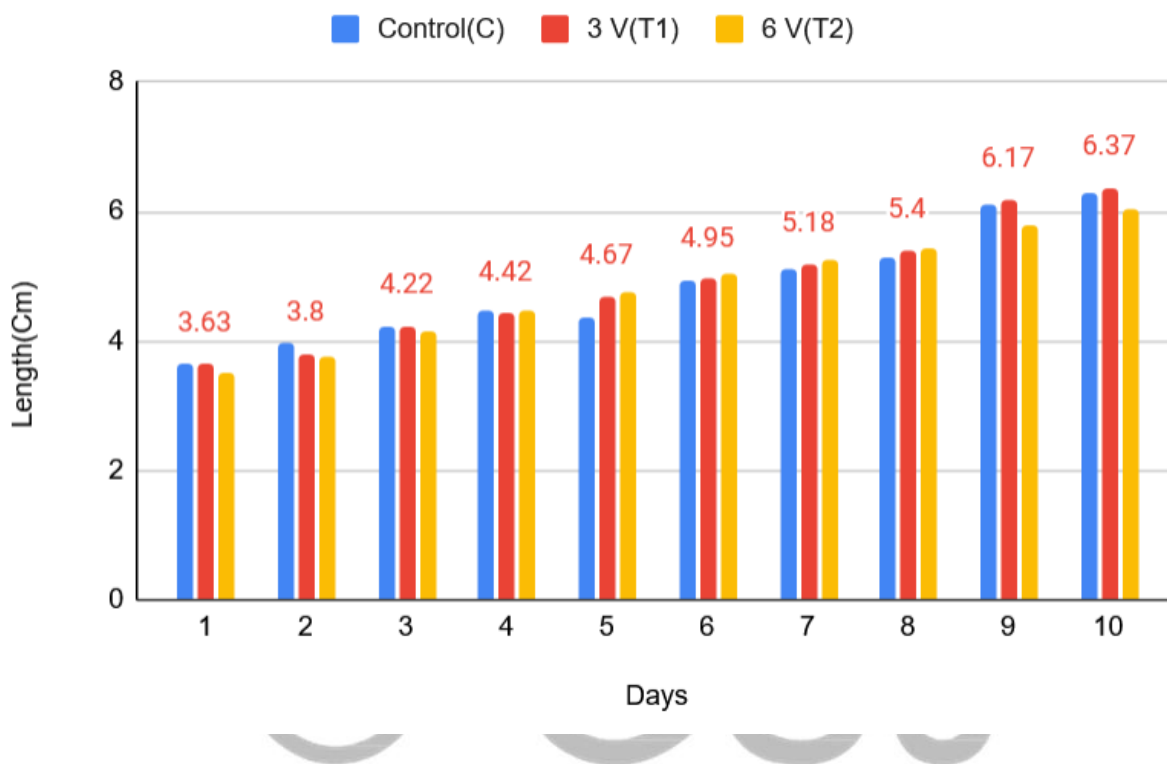
4. RESULTS AND DISCUSSION

4A – Plant Growth Performance

The mean height (cm) of the *Capsicum chinense* seedlings for Control (C), 3 V (T1) and 6 V (T2) treated plants were visually illustrated in Table 1 during the ten observation days. There is a general rise in average height of the plant which is normal and healthy in all treatments while the experiment is done. There was little to no variation across treatments throughout the first 4 days, indicating that electrical stimulation does not produce an effect immediately with early growth. Day 5 and onwards small differences started to emerge, with the 3 V group having a slightly higher mean height than the Control and 6 V. By Day 10, the mean height of 3 V treatment at 6.37 cm was higher than Control at 6.27 cm and that of 6 V group at 6.02 cm. In sum, these results indicate that mild 3 V electrical stimulation may yield an intermediate increase in early growth, while 6 V electrical stimulation resulted in similar but lower results, thus, indicating that milder stimulation is more optimal for *Capsicum chinense* seedlings.

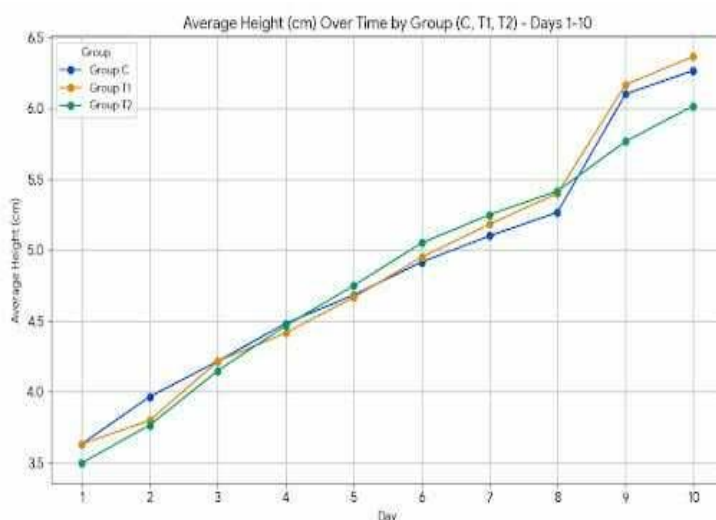
Day	Control(C)	3 V(T1)	6 V(T2)
1	3.63	3.63	3.5
2	3.97	3.8	3.77
3	4.22	4.22	4.15
4	4.48	4.42	4.47
5	4.35	4.67	4.75
6	4.92	4.95	5.05
7	5.1	5.18	5.25
8	5.27	5.4	5.42
9	6.1	6.17	5.77
10	6.27	6.37	6.02

This bar graph illustrates the average plant height of *Capsicum chinense* seedlings across ten (10) days under three treatments: Control (0 V), Treatment 1 (3 V), and Treatment 2 (6 V). The graph shows a steady increase in height for all treatments over time, with no significant difference among the voltage groups. The Control group displayed the highest mean height overall, while the 3 V treatment showed a slightly higher average than the 6 V group, indicating that mild electrical stimulation did not adversely affect plant growth.



4B – Overall Growth Trend

Mean heights of seedlings in all treatments were comparable at baseline (approx 3.5–4.0 cm). On Day 10, total increase in height was obtained for all treatments with the no stimulation control exhibiting the highest average height which was followed by the 3 V and 6 V treatments as a mean value.



4C – Statistical Analysis

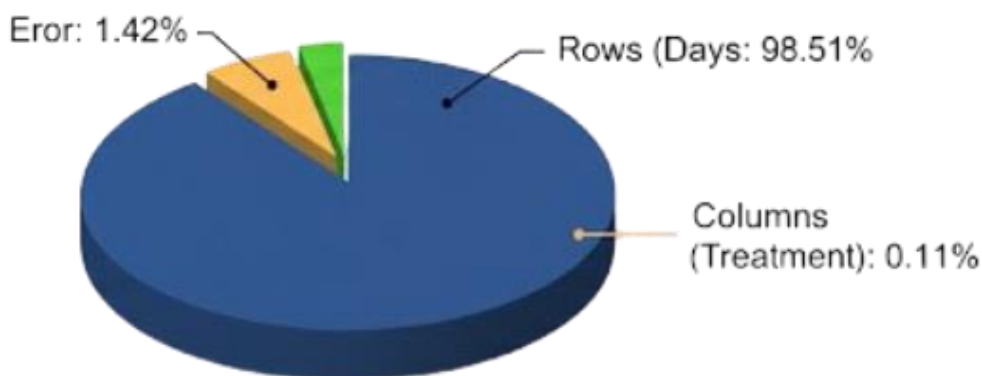
Two-way ANOVA was conducted to ascertain whether the influence of voltage level (treatment) and time (days) on plant height was significant. The significant effect of time ($p < 0.05$) was detected, suggesting that plant height grew progressively over the 10 days. Yet the effect of voltage level was not statistically significant ($p > 0.05$), suggesting that the mild electrical stimulation at 3 V and 6 V was not capable of eliciting a discernible difference in growth (compared to control) between the experimental conditions.

Subsequent post-hoc comparison via Tukey's HSD test indicated both treatment groups increased height from Day 1 to Day 10, but there was no significant difference between treatment of different voltage.

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Rows(Days)	20.60080333	9	2.288978148	139.2761752	0	2.456281149
Columns(Treatment)	0.0237066667	2	0.01185333333	0.7212331546	0.4996781411	3.554557146
Error	0.2958266667	18	0.01643481481			
Total	20.92033667	29				

This pie graph shows the contribution of each source of variation to the total sum of squares based on the results from the Two-Way ANOVA. As it can be seen, the highest variation, (98.47%), is assigned to time (Days), showing a much upward trend in height of the plant in the days thereafter. Treatment (voltage) explained only 0.11% of total variation, suggesting that mild electrical stimulation had negligible effects on growth. The remaining 1.42 percent describes random experimental error.

ANOVA SS Contribution



4D – Growth Pattern Interpretation

From Day 1 to Day 4, all seedlings did develop in an equal manner. Both stimulated groups

at Day 5 started with the same gradual increase in height as the control. The mean heights at Day 10 were as follows:

- Control (C): 6.1 cm \pm 1.1
- 3 V (T1): 6.4 cm \pm 1.2
- 6 V (T2): 5.9 cm \pm 1.0

While the mean height was marginally taller for T1 (3 V) than for T2 (6 V), both were in the same range as the control. Our results suggest that gentle electrical stimulation was not growth retardant and these plants were very tolerant of low voltage currents. The standard leaf colour and morphology was preserved and consistent throughout the experiment which confirms that electrical effects at these voltages were not harmful. This is consistent with Yi et al. (2012) which found that when pulses are kept at low voltage it can affect soil microbial communities and plant physiology with no apparent stress.

4E – Comparison with Previous Studies

The results of this experiment align with those of Li et al. (2019) and Lee and Oh (2020) concluded an enhanced physiological response to a low level of electrical stimulation in plants. However, unlike these studies, growth enhancement in this study was not statistically significant, potentially related to a short term duration of 10 days and low voltage intensity. In addition, Volkov (2007) and Scopa et al. (2009) state that plant ion transport and membrane potentials are influenced by electrical currents. The lack of a marked response in this study may indicate that the magnitude of 3–6 V currents is below the threshold required to induce detectable physiological alterations in *Capsicum chinense* seedlings.

4F – Overall Findings

It was found that *Capsicum chinense* seedlings react with normal behavior towards mild electrical stimulation, exhibiting growth similar to unstimulated plants. A safe voltage range of 3–6 V DC exhibited no severe harmful effects, indicating that such an exposure is non-hazardous and feasible in a small-scale agricultural installation. Longer-term and higher voltage range studies might yield data as to the threshold where electrical stimulation begins to significantly affect growth rate and physiology.

5. CONCLUSION

The effects of mild electrical stimulation, at voltages of 3 V and 6 V were also tested in *Capsicum chinense* seedlings at the beginning of growth. It was found, from the results obtained, that all treatments as well as the control exhibited healthy growth and continuous growth over the 10-day observation period. Nevertheless, statistical analysis indicated that the electrical stimulation was not able to significantly increase the height of plants over the control plant, as there were no significant differences between the different treatments. Although it failed to demonstrate a predicted improvement with respect to growth, the experiment has shown that low-voltage electrostimulation is safe and does not harm *Capsicum chinense*. The plants remained in good condition, showing no visible stress or decline in health. This finding also confirms the findings of Yi et al. (2012) and Li et al. (2019), the study found gentle voltages to stimulate plant development without harming the plant, however the impact may not be uniform across duration and for individual and species plants. The research also demonstrated that an inexpensive, uncomplicated and environmentally friendly electrical setup was indeed possible using elementary constituents, batteries, copper wires and nails. Although the anticipated improvement was not achieved, this experiment offered good practical knowledge of electrical stimulation on planting facilities and the minimum safety levels. Ultimately, although this process did not confirm potential for growth boosting, it did confirm that the technique was safe and practical and would contribute economic value. Longer exposure times together with increased voltage ranges should be considered to identify best possible circumstances for obtaining measurable enhancements in plant height growth.

5. RECOMMENDATION

From these findings, it can be concluded that in future research on the use of mild electrical stimulation for *Capsicum chinense*, the experimental duration on the long-term impact of plant growth should be considered for extension. A longer development time will enable more differentiation of treatments and a uniformity of growth. Further experiments with voltages beyond 3 V and 6 V would also be the best way to see what level would be able to induce a distinct physiological response and to check what was observed. To maintain the integrity of data generation, the inclusion of an automated or regulated power supply would provide a more predictable electrical feedback for every unit of electrical output that is introduced. Though plant height was chosen as the main growth indicator in this study, future studies might explore alternative measures such as chlorophyll content and root length in a controlled environment to better visualize electrical effects on plant physiology. Copper or graphite, two other materials with higher conductivity in an electrode, can also be considered to achieve a more uniform current distribution for the same system. Moreover, research performed on different soil types or moisture levels can lead to better understanding of the effect of environmental conditions on electrostimulation efficacy. Finally, repeat studies with different environmental and laboratory conditions in order to check the consistency of the results would also be valuable. Future studies could further refine the setup and other experimental variables to determine the optimal use of mild electrical stimulation as a sustainable and practical method to promote early growth of *Capsicum chinense*.

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