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Comparing Study of Different Dielectric Materials on the Electrical Discharge Plasma Generation and its Application for Seed Germination Improvement

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Abstract

This thesis aims to improve applications in industrial, helpful, and environmental domains through investigating the effects of two dielectric materials, glass and quartz, on the production and properties of dielectric barrier discharge (DBD) plasma. The non-thermal DBD plasma is produced by passing a high voltage across the dielectric barrier that uses copper tape as the electrodes. An important factor influencing the properties and effectiveness of plasma creation is the dielectric material. The aim of this research is to methodically examine how the dielectric materials quartz and glass affect the creation and properties of DBD plasma. Through the analysis of these materials' effects. To be able to achieve this, the study proceeded to build a DBD plasma system using a 50 Hz, 240 V Neon Transformer power supply, and investigate the effects of quartz and glass dielectric materials on the production of DBD the plasma and assess the effectiveness of DBD plasma produced through different dielectric materials to improve mung bean seed germination. The process comprised building a plasma generating chamber with a junction box and comparing the dielectric materials' plasma start and maintenance characteristics through experiments. In contrast to quartz, which had plasma initiation at 1.70 kV and intensified at 2.98 kV, glass had plasma initiation at 1.04 kV and intensified at 2.38 kV.

1. Introduction

This review aims to centralize the hypotheses and present evidence to date regarding the effects of plasma treatments on seeds. To have a review specifically focused on seeds that is comprehensible to an interdisciplinary audience of biologists and plasma physicists, especially because plasma agriculture has been receiving more attention nowadays. The "Comparative Study of Different Dielectric Materials on The Electrical Discharge Plasma Generation and its Application for Seed Germination Improvement" represents an innovative approach to enhancing agricultural practices by leveraging cutting-edge technology. This system employs electrical discharge 2 plasma—a state of matter composed of ionized gases—to positively impact the germination process of seeds. The method involves the interaction between a copper electrode and dielectric material, creating a controlled electrical discharge plasma that is directed towards seeds. To overcome these difficulties, the "Comparative Study of Different Dielectric Material on the Electrical Discharge Plasma System" was introduced. This system offers a regulated and focused method of promoting seed germination. s. Moreover, this technique can be applied in any environment, which means it can be a flexible solution for a wide range of crops and areas of the country.

An electric arc provides the heat needed for arc welding, a kind of fusion welding. In manual metal-arc welding, the current travels to the arc via a covered metal electrode that is shaped like a rod or wire. Without the right safety measures, manual metal arc welding may be dangerous. An open electric arc is created during the welding process between an electrode and the metals that need to be connected. In addition to the obvious hazards of burns and corneal irritation, which may be avoided by wearing the appropriate personal protective equipment, the operator may also run the risk of receiving an electric shock from the exposed electrode and workpiece in the welding circuit [1-2]. An investigation is conducted into the possibility of using the corona discharge mechanism to supply an electrical load for high-voltage low-current dc generators in experimental settings. Several corona discharge topologies, including wire-to-plane, coaxial cylindrical, and point-to-plane, had their current-voltage characteristics measured experimentally and compared to those predicted theoretically. The wire-toplane design, which is primarily dependent on the wire-to-plane spacing, is found to be capable of dissipating the most electrical power of all the configurations evaluated, which is over 3 kW/m of wire length. It also displays a wide range of current-voltage characteristics at different pressures. Their molecular structure plays a major role in the mechanism of these charged carriers' interactions with different surfaces, particularly photoconductors, since it can affect the species' ion-electron recombination energy (R. E.) [3].

The study of dielectric barrier discharge (DBD) plasma and its interaction with various dielectric materials, such as glass and quartz, is critical for advancing numerous applications in environmental, medical, and industrial fields. The dielectric material plays a crucial role in the characteristics and efficiency of plasma generation. The purpose of this study is to systematically investigate the influence of glass and quartz as dielectric materials on the production and characteristics of DBD plasma. By analyzing the effects of these materials, the study aims to enhance the understanding of the key factors that affect plasma generation and its properties, thereby providing insights that will enable the optimization and efficient design of DBD plasma systems for various applications. The main objective of this research is to suggest a basic Comparative Study of Different Dielectric Material on the Electrical Discharge Plasma System. The Specifically objectives are based on aim of this project.

This study aims to explore the development and application of a dielectric barrier discharge (DBD) plasma system for agricultural enhancement, particularly focusing on the germination of Mung Bean seeds. Specifically, the objectives of this research are threefold. First, it seeks to develop a DBD plasma system utilizing a 50 Hz, 240 V power supply in conjunction with a Neon Transformer. Second, the study aims to investigate the influence of different dielectric materials, namely glass and quartz, on the generation of DBD plasma. Finally, the effectiveness of DBD plasma generated by these dielectric materials in enhancing Mung Bean seed germination will be evaluated. By integrating these objectives, the research endeavors to provide a comprehensive understanding of the DBD plasma system's development, operational parameters, and practical agricultural applications.

The scope of this project is delineated to ensure a focused and manageable investigation into the development and application of a dielectric barrier discharge (DBD) plasma system for seed germination treatment. Specifically, the project encompasses the following aspects. First, the high voltage generation range for this study is limited to a maximum of 10 kV. Second, all experiments will be conducted with plasma generated at atmospheric pressure and using moderate energy levels. Third, the project will primarily concentrate on the construction of the power supply for the DBD plasma system, with a specific application in the treatment of Mung Bean seeds to enhance their germination. This defined scope ensures a targeted approach, facilitating detailed exploration and analysis within these parameters.

2. Methodology

2.1 Design development

The primary objective of the methodology is to provide an explanation of the project flow via the use of several outlines and the technique that will be employed to meet the objectives for the design of a chamber using junction box to ignite Electrical Discharge Plasma System for Seed Germination Improvement. This chapter describes the strategies that were employed to establish and achieve the project's objectives, as well as the development of the hardware and software for the project. The material in this chapter will be centered on the project workflow.

A flowchart that shows the project's development from start to finish will serve as the process representation. This chapter will give a summary of how high voltage develops from the 240V 50Hz to the transformer, which then increases current to produce a high voltage. The schematic circuit was tweaked and altered in this study to accomplish the desired goal, although there was originally adopted from a typical electric fence circuit. The flowchart in figure 1 will be shown in the section that follows the simulation.

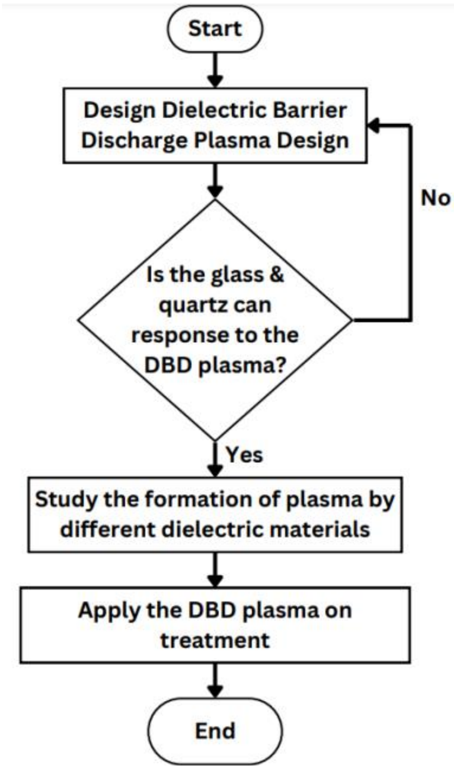

Figure 1: Flowchart of the Dielectric Barrier Discharge Palsma Design

The flowchart above demonstrates how the study perform is structured into a series of carefully procedures for creating and assessing a dielectric barrier discharge (DBD) plasma system for seed germination treatment. A DBD plasma system is designed and developed all through the process's initial design phase. This entails building a power source and choosing the right substances and parts required to produce DBD plasma at the designated voltage levels and air pressure conditions. After the initial design phase, there is a significant testing stage when the DBD plasma responsiveness of the chosen dielectric materials (quartz and glass) is determined. To make sure the materials can sustain the creation of plasma, this stage is needed. In case that the materials do not react effectively, the design is repeated and improved upon until the intended plasma the creation is carried out.

After a successful testing of the response of the dielectric materials, an intensive study of the plasma formation helped by these materials is conducted. During this investigation, the plasma properties such as discharge configurations, energy distribution, and stability under the influence of glass and quartz dielectrics are identified. The knowledge acquired from this investigation is essential to knowing the operation and effectiveness of the plasma produced using different dielectric materials. Applying the DBD plasma system to seed germination treatment is the last stage in the process. Measurements of germination rates and other helpful measures of growth are used to assess the effectiveness of the plasma generated by the system design in treating Mung Bean seeds. In this application phase, the DBD plasma system's practicality is assessed and actual data regarding its effect on seed germination is presented.

2.2 Block diagram of the project

Figure 2 represents the full process of preparing this experiment for the construction of a junction box or device that produces plasma. An AC 240 V power source that uses high voltage has been provided to activate the circuit in this project that can generate plasma.

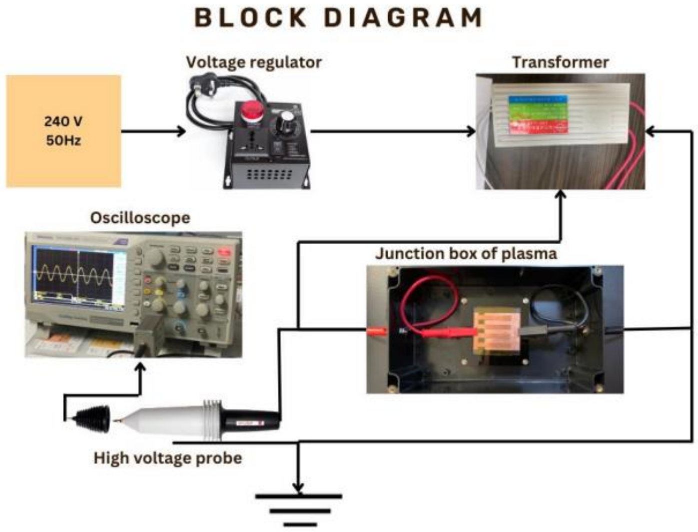

Figure 2: Block diagram of the project

When the power supply reaches a high voltage, a voltage regulator works to make sure the voltage stays consistent. On the other hand, the transformer receives a connection from the voltage regulator and also use to increase the voltage to the maximum needed to produce plasma. After the voltage is raised to the voltage regulator's maximum power, the plasma appears. Subsequently, the outcome of plasma is visible through the junction box, which is outfitted with parts such an insulated crocodile clip on the inside and an exterior banana connector that links both. The plasma then requires a dielectric material, which is a digitalized copper tape, to be attached to it to be seen more clearly. After that, clip the dielectric material into position on the stage contained in the box. In addition, waveform reading is essential for determining the amount of kV voltage applied to the dielectric material to generate plasma, and an oscilloscope is a must for this project. High voltage is utilized in this project to read data from the oscilloscope and identify waveforms and signals up to 10 kV.

2.3 Schematic diagram of the project

Figures 3 and 4 show the schematic diagram's relationship to the main components of this study as well as the whole prototype.

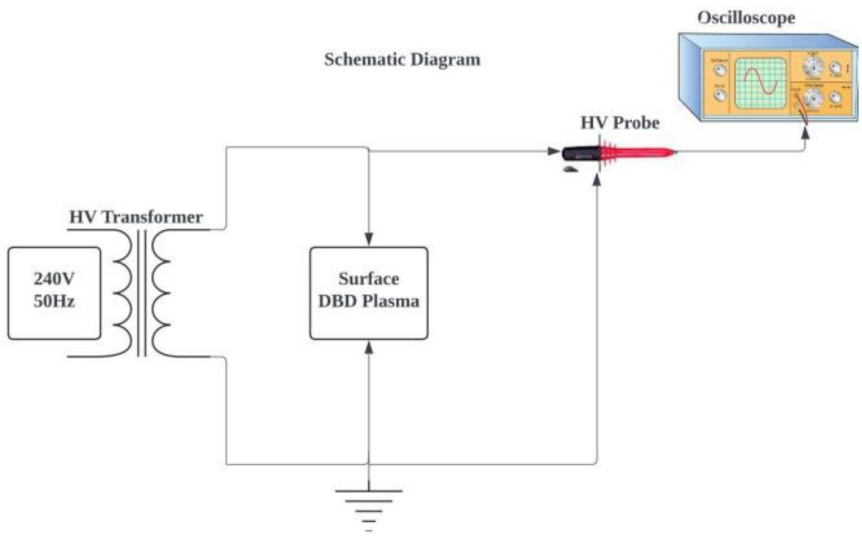

Figure 3: Schematic diagram of the project

The experimental design aimed to prepare seed germination that uses surface dielectric barrier discharge (DBD) plasma is schematically diagrammed in Figure 3. This configuration consists of an oscilloscope, a surface DBD plasma unit, an HV probe, and a high voltage (HV) transformer. Every component is essential to the efficient production and injection of plasma for seed treatment. The purpose of the high voltage transformer is to raise the 240V, 50Hz input voltage to a much greater voltage needed to produce plasma. Because the breakdown voltage required to start a plasma discharge is much higher than the line voltage, this change is necessary. The ionization of the gas between the electrodes by the electric field created when a high voltage is placed across both results in the production of plasma. The dielectric barrier ensures a stable plasma appearance by preventing arcing and helping to disperse the discharge uniformly.

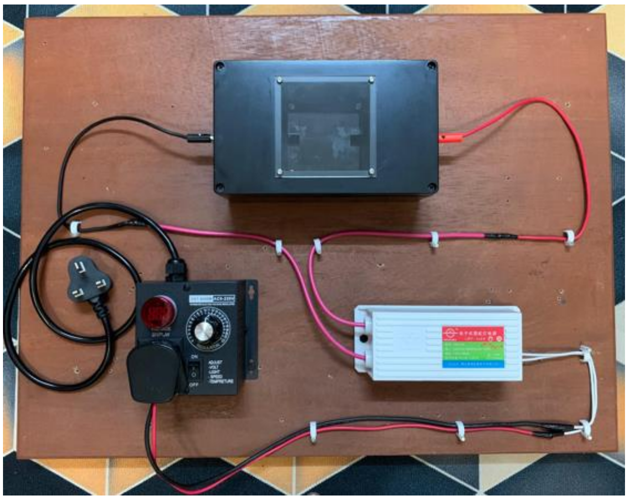

Figure 4: Design actual protoype of the project

Subsequently, the DBD plasma unit and the HV probe are linked in parallel to detect the high voltage across the electrodes. The purpose of this probe is to accurately and safely measure high voltages and give the oscilloscope readings. Visualizing and analysing the voltage waveform applied to the DBD plasma unit is done with an oscilloscope. There were shows the sinusoidal waveform, which enables researchers to monitor the voltage from peak to peak and make sure it fulfils the necessary specifications for plasma start and maintenance. Put the system together in accordance with the schematic drawings, making sure that every connection is safe and insulated to avoid electrical risks. Which is important that the oscilloscope and DBD plasma unit are connected to the HV probe correctly. Then place the seeds in a uniform layer on the surface of the dielectric material within the DBD plasma unit. Ensure that the seeds are evenly distributed to receive uniform plasma exposure. Depending on the experimental requirements, the dielectric material may be adjusted to vary the distance between the seeds and the electrodes, affecting the intensity and distribution of the plasma.

3. Result and discussion

The results and discussion analysis in this chapter focus on the data obtained from the Comparative Study of Different Dielectric Materials on The Electrical Discharge Plasma Generation and its Application for Seed Germination Improvement. The discussion begins with the formation of electrical discharge plasma by glass and quartz as dielectric material and the. Furthermore, comparison between glass and quartz as dielectric material to produce DBD plasma and explained. Lastly, the application of DBD plasma on seed treatment for germination improvement and rate analysed.

3.1 Formation of electrical discharge plasma by glass and quartz as dielectric material

When glass and quartz is used as a dielectric material and copper the electrodes to see or study when the plasma was start to initiate and intense remain full voltage, a powerful electricity field must be created across a glass and quartz layer as thick as 1 mm in to ionize the surrounding gas and create electrical discharge plasma. Glass and quartz are a helpful obstacle in dielectric barrier discharge (DBD) installations because of its strong dielectric strength and stability.

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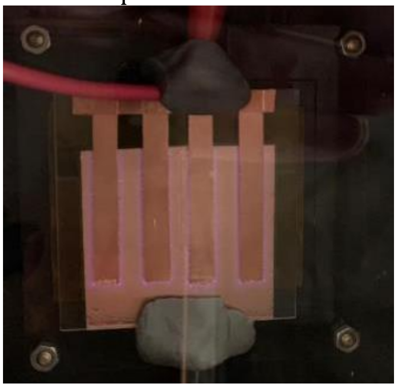
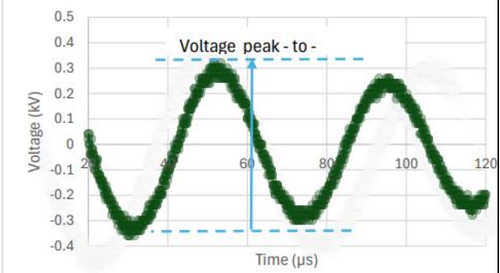
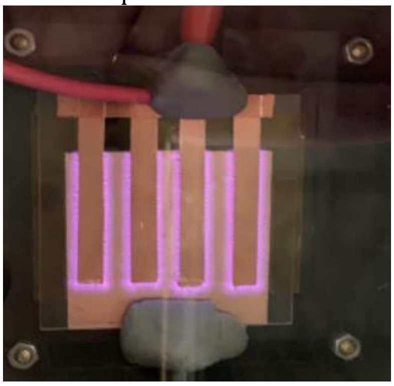
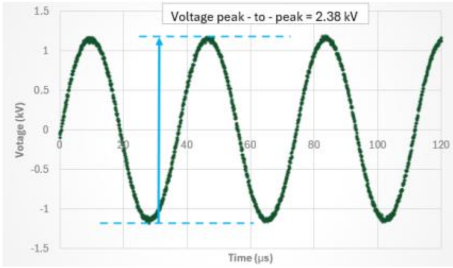
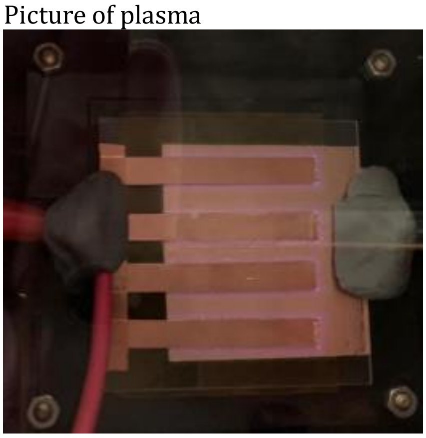
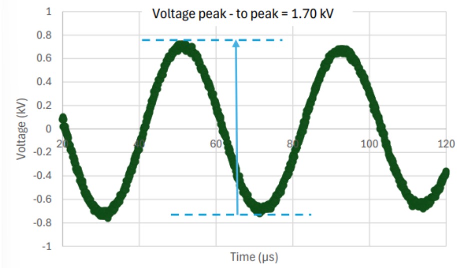
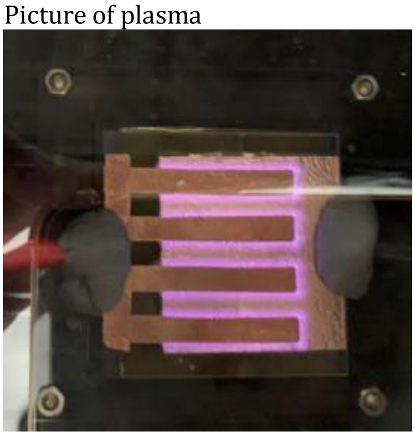
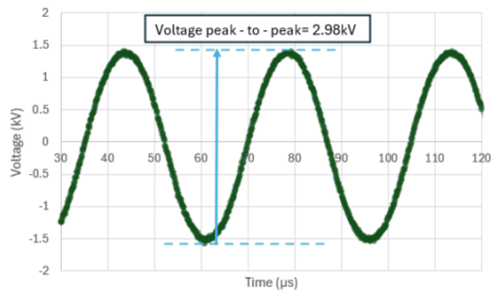
Table 1: Formation of electrical discharge plasma by glass and quartz as dielectric material

<table>
<tr><td>Dielectric material</td><td>Start to initiate</td><td>Remain intense</td></tr>
<tr><td>Glass</td><td>Picture of plasma

Sinusoidal waveform 1.04kV
</td><td>Picture of plasma

Sinusoidal waveform 2.38kV
</td></tr>
<tr><td>Quartz</td><td>Picture of plasma

Sinusoidal waveform 1.70kV
</td><td>Picture of plasma

Sinusoidal waveform 2.98kV
</td></tr>
</table>

When compared to glass, quartz has a lower permittivity (dielectric constant). Since the electric field is less concentrated inside the dielectric layer due to the lower permittivity, a greater voltage is needed to produce the same degree of electric field intensity that is required for plasma start. The 2.98 kV intensification voltage marks the point where the plasma becomes sustainable and more visible. Due to its great dielectric strength, quartz is resistant to dielectric breakdown even when exposed to strong electric fields. Because quartz has a higher dielectric strength than other materials, like glass, it can handle a higher sustaining voltage of 2.38 kV, indicating that a stronger electric field is needed to ignite plasma. Because of this characteristic, quartz is a strong dielectric barrier that is suitable for high voltage applications.

3.2 Comparison between glass and quartz as dielectric material to produce DBD plasma

The investigation demonstrates that dielectric materials have significant effects on the generation of dielectric barrier discharge (DBD) plasma, as evidenced by the different performance of quartz and glass.

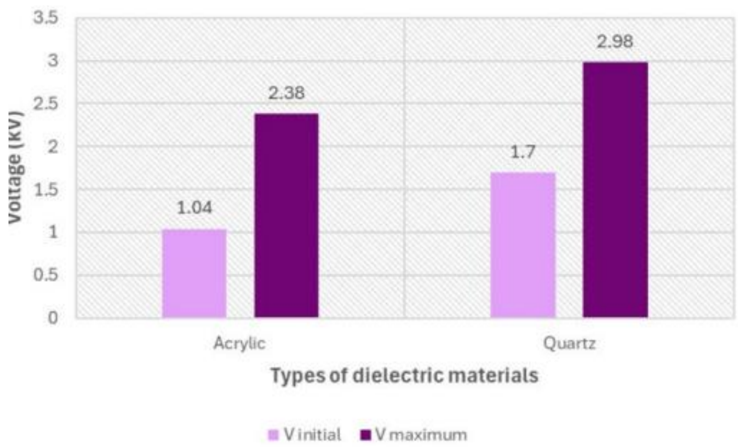


Figure 5: The comparison between glass and quartz

When it came to plasma generation, glass showed a significantly lower initiation voltage (1.04 kV) than quartz (1.70 kV). The materials' present dielectric qualities are responsible for the difference. Glass allows for earlier plasma initiation because of its lower dielectric constant (between 2.5 and 3.5), which produces a greater electric field for a given applied voltage. Moreover, glass can experience electrical breakdown and generate plasma at lower voltages because of its lower dielectric breakdown strength (around 20–25 kV/mm) in comparison to quartz (about 40–50 kV/mm). In DBD plasma applications, the selection of dielectric material is based on the individual demands. Quartz is chosen for high-power applications despite its higher voltage needs because of its superior mechanical and thermal stability, while glass is best suited for low-voltage applications because of its lower initiating voltage and cost. These results underline the importance of choosing suitable materials depending on application-specific requirements and emphasize the crucial role that dielectric characteristics play in maximizing DBD plasma creation.

3.3 Application od DBD plasma on seed treatment for germination improvement

A high voltage plasma is applied to seeds in Figure 6 to produce germination using surfaces dielectric barrier discharge (DBD) plasma treatment.

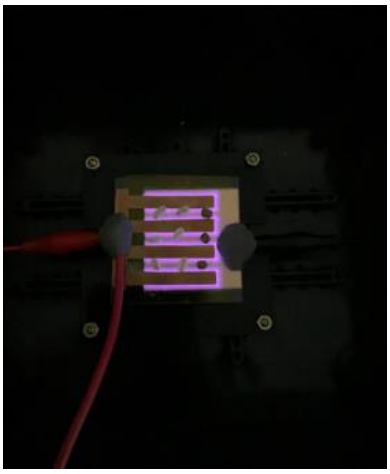


Figure 6: The seed that exposures to the plasma that sustain at the high voltage

The process, effects that have been seen, and ramifications of employing DBD plasma to improve seed germination. As seen in the experimental setup, a high voltage is used to begin the plasma. The plasma initiation voltage for quartz dielectric material is measured to be approximately 1.70 kV, and its peak intensity is attained at 2.98 kV. A steady and even plasma discharge across the seed surface is protected by this high voltage. The seeds were first evenly exposed to the plasma by putting them on the dielectric surface. All seeds receive consistent treatment because of the digitated electrode arrangement, which ensures that the plasma is spread uniformly. Plasma-treated seeds generally display more effective early seedling growth in addition to increased germination rates. This represents improved general strength, quick emergence, plant longer roots and shoots. These positive findings are a result of the increased consumption of nutrients and decreased load of bacteria.

4. Conclusion

The aim of this investigation was to design a dielectric barrier discharge (DBD) plasma system with a neon transformer and a 50 Hz, 240 V power supply. The objective of plasma generating was effectively completed by the systematic setup and operation of the DBD plasma system, which included an application of quartz as a dielectric material. The stable initiation and sustained of plasma at specific skills voltage levels proved the effectiveness of the system, and the improved germination and growth of seeds observed in experimentation further confirmed its positive effects. It is therefore clear that the creation of the DBD plasma system with the designated power supply was completed successfully, hence fulfilling the stated objective.

Investigating the effects of quartz and glass dielectric materials on the production of dielectric barrier discharge (DBD) plasma was the investigation related aim. Through a few tests and observations, this objective was successfully achieved. The findings showed that the two dielectric materials differed significantly in terms of the voltage thresholds needed to initiate plasma and the intensity of plasma formation. Quartz needed a greater initiation voltage (1.70 kV) and maintained plasma at a higher intensity at a maximum 2.98 kV, whereas glass-initiated plasma at a lower voltage (1.04 kV) and sustained it with greater intensity at 2.38 kV.

Next, thing that can conclude is purpose was to determine how much DBD plasma produced through different dielectric materials may improve the germination of mung bean seeds. Through comparative studies using quartz and glass as dielectric materials, this objective was successfully met. The outcomes showed that when seeds were exposed to DBD plasma, germination rates and growth patterns were improved. Interestingly, quartz has been shown to be more successful than glass at improving seed germination, as seen by the strong and quick development that occurred over the course of three days. These findings support the theory that DBD plasma greatly accelerates the germination and early growth of mung bean seeds, especially when produced using quartz dielectric material.

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