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Improvement in Bengal Gram (Cicer Arietinum) Seed Germination and Crop Growth through High Voltage Treatment

Rejo Roy[1], Albert John Varghese[1*], Nagvendra Kanoje[2], Satyadharma Bharti[1]
[1]Department of Electrical Engineering, [2]Department of Mechanical Engineering
Rungta College of Engineering & Technology, Bhilai, Chattisgarh, India
*Corresponding Author – ajvberty@gmail.com

Abstract:
The global economy is facing significant challenges related to food scarcity, water scarcity, reduced land availability, and climate change. These challenges necessitate innovative approaches in agriculture to ensure sustainable food production and environmental stewardship. Electro-culture is a technique that uses high voltage electrostatic fields to improve seed germination and crop growth. Electro-culture has emerged as a promising approach for promoting plant growth without relying on chemical interventions. This study aims to evaluate the impact of a high voltage electrostatic field (20 kV) on the germination and growth of Cicer Arietinum (Bengal Gram). Germination booster plates are used to create a uniform field of 5 kV/cm having a gap of 4 cm. Experimental results demonstrated that the treatment of seeds using 20 kV for 120 seconds yielded superior outcomes compared to the treatment of 20 kV for 240 seconds. These findings highlight the potential of high voltage treatments to enhance seed germination and crop growth in Bengal Gram, offering a sustainable, efficient, and adaptable approach to agricultural practices, addressing environmental concerns, enhancing productivity, and promoting resource efficiency.

Keywords: High Voltage Seed Treatment, Germination Enhancement, Improved Crop Growth, Electrostatic Field, Soaked Seed Treatment

Introduction:

High voltage electric power transmission lines serves as the backbone of electricity distribution, delivering power from generating stations to various regions, they cover extensive areas of agricultural land, intersecting fields, pastures, and forests. The response of individual plant species, as well as different varieties, to the electromagnetic field can vary significantly, resulting in diverse manifestations. The investigation into the influence of electricity on plant growth led to some notable discoveries regarding the agricultural applications of electricity, including its use in seed treatment, seedling growth, plant development, and insect control, among other purposes. Electro-culture techniques have demonstrated the potential to provide protection for plants against diseases, insects, and frost. Moreover, these methods have the ability to minimize the reliance on fertilizers and pesticides in agricultural practices.

In agricultural applications, different high voltages electrostatic fields can produce varying biological effects on different species. Some of the agricultural applications include promoting seed germination, accelerating plant growth, inactivating bacteria in soil and liquid

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hydroponic media, and facilitating fruit-body formation in crops such as mushrooms and fruits during the pre-harvest phase. It also helps in maintaining post-harvest freshness of agricultural products, which is crucial for a sustainable food supply chain. Based on the literature review carried out, some of the studies conducted utilizing high voltages are as summarized below:

- Explore the influence of varying electromagnetic field intensity on the growth and development of bean plants, it also investigates the biometrical parameters, plant productivity, yield, dry matter accumulation, photosynthetic pigments content, ascorbic acid levels, total antioxidant activity, and total phenolic compounds. [1]
- The contact conditions of wheat seeds with a plane aluminum electrode, including no contact, contact with the positive or negative high-voltage electrode, and contact with the grounded electrode is compared. The contact conditions during spring wheat seed treatment using a constant electric field are crucial and is evaluated based on the morphological characteristics of 3-day seedlings, specifically germination, shoot length, and individual root length. [2]
- Presence of high-voltage transmission lines with large current levels generates electric and magnetic fields in the surrounding vicinity. The biochemical alterations induced in plants by electromagnetic fields (EMFs) have a significant impact on crop production, resulting in potential economic losses. [3]
- Application of a high-voltage electrostatic field (HVEF) has shown positive effects on seed germination in various studies. Utilizing HVEF instead of chemicals can significantly contribute to environmental protection. [4]
- Exploring the potential role of electromagnetic fields (EMF) from power lines in optimizing bio-stimulation and understand its effects. The impact of EMF on plant growth parameters demonstrates that both mustard and sugarcane plants exhibit enhanced growth characteristics within a 30-meter distance from the power line. [5]
- Three distinct methods, namely electrostatic field, microwave, and corona discharge, were employed to treat tomato seeds. It was determined that the application of electrostatic field treatment exhibited improvements in germination rates, root and shoot length, as well as seed vigor. [6]
- To improve germination and enhance the quality of young pine seedlings, an electrostatic field treatment was employed in combination with gibberellic acid (GA3) soaking at a concentration of 100 ppm. This demonstrated improved germination rates, increased seedling height, and enhanced root length during the initial germination stage as well as the middle and later stages of seedling development. [7]

Seeds play a vital role in ensuring the sustainability of plant species and varieties. Enhancing germination rates and considering the influence of environmental conditions in various applications can prolong the duration and effectiveness of their effects. To promote successful seed germination and seedling growth, the application of positive electrostatic field treatment has been found to induce beneficial electrical and biochemical changes. The proposed work aims to study the effect on seed germination without adverse effects, offering a promising avenue for improving crop productivity. Ultimately, this research endeavors to contribute to

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the ongoing efforts to ensure food security and sustainable agriculture in an increasingly resource-constrained world.

Methodology:

The methodology outlined aims to investigate the impact of high-voltage electrostatic field treatment on seed germination and subsequent crop growth. This study utilized a controlled experimental setup to compare the treated and untreated seeds for the evaluation of the effects of the electrostatic field on Cicer Arietinum i.e, bengal gram seeds. The steps to be followed are as listed below:

a. **Selection of Seeds:** A total of 90 seeds (normal seeds used for consumption from grocery stores) were selected, which were further divided into three equal portions of 30 seeds each.
b. **Electrostatic Field Treatment:** The selected seeds underwent electrostatic field treatment using a high-voltage source. Figure 1 shows the block diagram for high voltage field and booster plate setup.

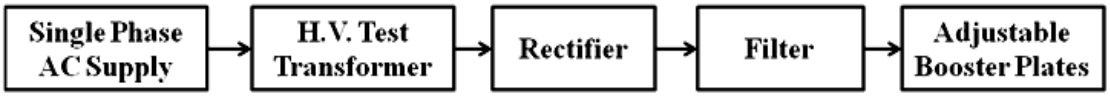

Fig. 1 : Block Diagram for Implementation of High Voltage Field Treatment

c. **Experimental Design:** The seeds were divided into three categories, and each category was subjected to a different treatment process. The categories included: untreated seeds (C3), seeds treated for 120 seconds (C1), and seeds treated for 240 seconds (C2). The separation gap between the booster plates should be maintained.
d. **Germination and Growth Observation:** After the electrostatic field treatment, the seeds were kept in a dark room for 10 days to observe germination and early seedling growth. The growth characteristics such as germination rate were recorded.
e. **Soil Testing and Crop Evaluation:** Some additional steps, such as soil testing of the field, evaluation of crop yield, and the determination of various soil parameters including pH level, electrical conductivity, and water holding capacity.
f. **Data Analysis:** The experimental data obtained from the germination and growth observations were statistically analyzed to determine the effects of the electric field on the seeds. Comparisons were made between the treated and untreated seeds, and the influence of high voltage treatment was evaluated.

Application of Developed Methodology:

Cicer Arietinum (Bengal Gram) seeds were used in this study. A total of 90 seeds were divided into three equal portions of 30 seeds each. Each portion was measured to have an approximate weight of 5.5 grams. The first portion of 30 seeds (C1) was subjected to a 20 kV electric field for 120 seconds. The second portion of 30 seeds (C2) was treated with a 20 kV electric field for 240 seconds. The final portion of 30 seeds (C3) was left untreated and served as the control group.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12,Dec 2022

Table 1: Components required for implementing the High Voltage Treatment Circuit

Components	**Value/Range**
Single Phase AC Source	220V, 50Hz
Variac	0-220V
Voltmeter	0-100kV (Calibrated)
H.V. Test Transformer	Two Cascaded Transformers (5MVA)
Rectifier	140kV
Filter Capacitor	3300pF
Booster Plates	Gap Length Adjustable

The booster plates used in the experiment were separated by a distance of 4 cm. The experimental setup consisted of a high-voltage power source, booster plates, and seed samples. Table 1 shows the list of components used for implementing the High Voltage Treatment Circuit. Figure 2 shows the hardware implementation of the High Voltage Treatment Circuit. The circuit should have an adjustable plate arrangement.

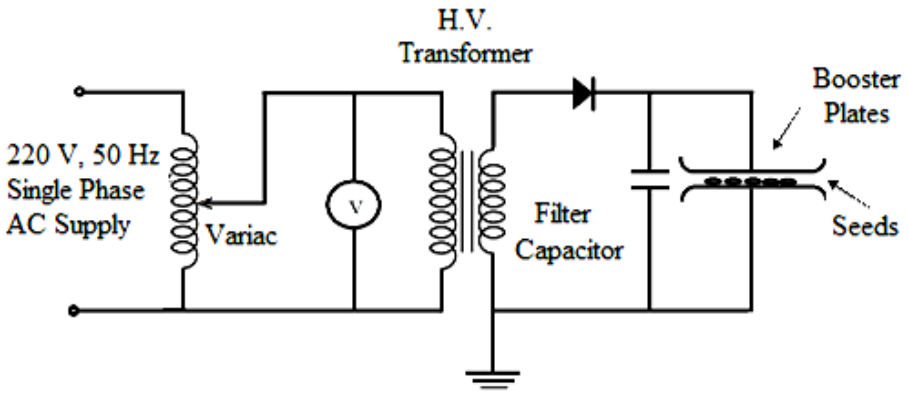

Fig. 2: High Voltage Circuit for Seed Treatment

Different voltage intensities and durations were applied to determine the optimal conditions for promoting seed germination and crop growth. Germination rates, seedling vigor, root and shoot growth was evaluated as key parameters. Some physical parameters of the soil where the experiment was carried out were performed. Table 2 shows the measured values of the physical parameters of the soil.

Table 2: Physical Parameters of Soil

Parameter	**Measured Value**
pH Level	6.4 (nearly alkaline)
Electrical Conductance	0.02 Seimens/Meter
Water Holding Capacity	387.26mm (in the first meter below surface)

The treated seeds were kept in a dark room for 10 days. Soil plays a vital role in providing support, water, and nutrients to plants. An area of land measuring 5m x 15m was prepared for sowing. The ground was ploughed thoroughly no fertilizers were added and it was divided into 3 sections. Each section of the land had seeds placed in a separation gap of 6 inches. The weather conditions at the time of sowing were partly cloudy, with a temperature of 26°C.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12,Dec 2022

Adequate water was sprinkled over the seeds to ensure appropriate moisture levels. The seeds were sprinkled with water daily and environmental readings taken on regular intervals.

Results and Discussions:

Seed germination and crop growth are critical stages in plant development that directly influence overall crop productivity and quality. The results demonstrated that high-voltage electrostatic field treatment significantly improved plant development. The experimental study was carried out successfully. The influence of high-voltage electrostatic field treatment on crop productivity was evaluated by assessing yield-related parameters. The treated crop plants demonstrated higher productivity levels compared to the control group. Figure 3 shows the crop growth status after a period of 80 days.

Fig. 3: Crop Status after 80 days

The relative humidity and temperature patterns follow a typical daily cycle. Sun plays a crucial role in influencing both temperature and humidity levels. Its presence and intensity impact the heating of the Earth's surface, which in turn affects the capacity of the air to hold moisture. Understanding these daily cycles can be important for agricultural activities. Table 3 shows the variation of temperature and humidity over the period of crop growth.

Table 3: Temperature & Humidity Variation during Crop Growth

Date	Temperature (°C)	Humidity (%)
15/11/2021	31	53
20/11/2021	33	54
25/11/2021	30	52
30/11/2021	27	42
05/12/2021	28	60
10/12/2021	25	70
15/12/2021	27	40
20/12/2021	24	29
25/12/2021	27	54
30/12/2021	19	90
05/01/2022	27	50
10/01/2022	22	84
15/01/2022	22	76
20/01/2022	27	36

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12,Dec 2022

25/01/2022	24	46
30/01/2022	27	32
05/02/2022	26	24
10/02/2022	27	63
15/02/2022	29	34
20/02/2022	30	36
25/02/2022	32	33
05/03/2022	33	32
10/03/2022	34	24
15/03/2022	38	28
20/03/2022	37	36
25/03/2022	36	37

Figure 4 illustrates graphically the temperature & humidity variation during crop growth. The temperature and humidity values were recorded using online tools for the crop location.

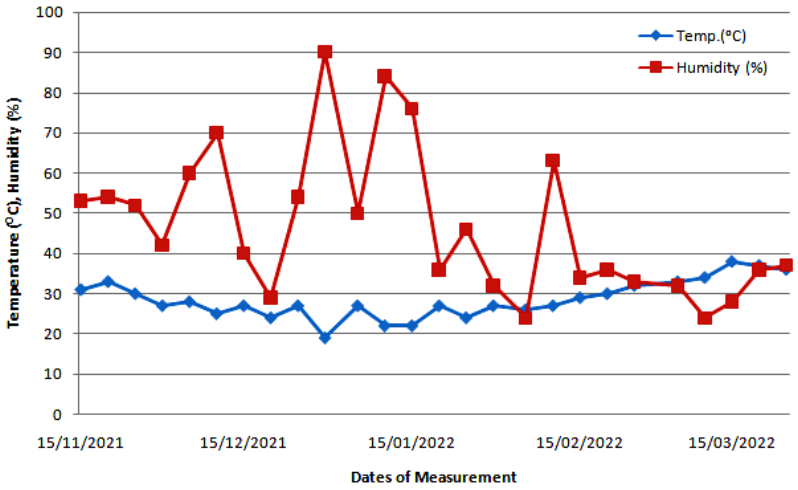

Fig. 4: Temperature & Humidity Variation during Crop Growth

There was a significant increase in the number of fruits or pods produced, as well as the overall weight of the harvested crop. Table 4 shows the quantitative analysis of the crop after a period of 130 days from the date of sowing.

Table 4: Crop Growth Quantitative Analysis

Crop Section	**Total no. of Plants (X)**	**Total No. of Bengal gram pods (Y)**	**Average Pods per Plant (Y/X)**
C1 (120 Sec)	13	49	3.77
C2 (240 Sec)	11	30	2.72
C3 (Reference)	10	13	1.30

The growth compared to conventional farming practices is less but noteworthy because of the following factors:

- ✓ Land used was barren without any agricultural activity for years

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12,Dec 2022

- ✓ Seeds used were not certified or purchased from agricultural shops
- ✓ Fertilizers or manure were not used before or after planting.

The treated seeds consistently outperformed the untreated seeds in terms of germination rates, seedling growth, and crop productivity. This highlights the potential of high-voltage treatment as a means to enhance seed quality and improve agricultural productivity.

Conclusions and Future Scope:

The experimental results showed that the application of high-voltage electrostatic field treatment had a significant impact on seed germination and crop growth rates of Cicer Arietinum (Bengal Gram) seeds. The treated seeds planted in Section C1 (i.e., crops treated 20 kV electric field for 120 seconds with a plate distance of 4 cm) exhibited higher germination and crop growth percentages compared to the reference (i.e., untreated) group. This suggests that the electrostatic field stimulation provided by the high-voltage treatment enhanced the metabolic processes. An interesting observation from the study is that the positive effects on germination and crop growth were achieved without the use of fertilizers or manures. This indicates the potential of high-voltage treatment as an environmentally friendly and sustainable approach in agriculture.

The work can be further improved by field trials and large-scale experiments to validate the effectiveness and practical application of high-voltage treatment in real-world agricultural settings. Also studies can be conducted to identify the optimal electric field parameters for different plant species. Such investigations can help refine the application of high-voltage treatment and maximize its benefits in agricultural practices.

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