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Effects of Electroculture Antennas on Okra Growth and Yield Performance

Afusat Omolabake Atanda[1*], Abdullateef Ola Abdullateef[2], Kudirat Abiola Abdullahi[3], Tunde Abdulsalman Saliu[4] & Adebayo Issa Aremu[5]

[1,5]Department of Agricultural Technology, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin, Nigeria

[2,3,4]Department of Electrical/Electronic Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin, Nigeria

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ABSTRACT **Original research paper**

While conventional agricultural methods continue to face challenges in sustainable crop production, electroculture technology utilizing electromagnetic fields has emerged as a promising approach for enhancing plant growth and yield, with previous studies reporting improved seed germination, enhanced photosynthesis, and increased biomass production in various crops. This study investigated the effects of pure copper electroculture antennas on growth performance and yield characteristics of okra (Abelmoschus esculentus L.) under controlled experimental conditions. Eighteen okra plants were arranged in a 6×3 grid configuration, with 12 plants receiving electroculture treatment through copper antennas installed at week 2 after transplanting from greenhouse-germinated seedlings, while 6 plants served as controls. Plant height, leaf count, fruit production, and individual fruit weights were monitored over 6 weeks. Results demonstrated that electroculture-treated plants achieved a remarkable 2.3-fold increase in total fruit production (156 vs 67 fruits) compared to controls, with sustained production across all harvest periods. While individual fruit weights were slightly lower in treated plants (32.8 ± 15.2g vs 35.4 ± 16.8g), vegetative growth showed modest improvements in final height (51.2 ± 6.8 cm vs 50.8 ± 6.7 cm) and leaf development. The findings suggest that pure copper electroculture antenna technology has significant potential for enhancing okra productivity by optimizing resource allocation toward increased fruit set and production consistency, offering a sustainable approach for improving crop yields without external energy requirements or synthetic inputs.

Keywords: Electroculture, Copper antenna, Okra, Sustainable agriculture, Electromagnetic fields, Crop productivity, Fruit yield.

**Corresponding author: Afusat Omolabake Atanda*

Department of Agricultural Technology, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin, Nigeria

1. Introduction

The growing global demand for sustainable agricultural practices has led to increased interest in alternative technologies that can enhance crop productivity while minimizing environmental impact. Electroculture, an emerging agricultural technique that utilizes atmospheric electrical energy and electromagnetic fields to stimulate plant growth, represents one such innovative approach that has gained renewed attention in recent years[1].

Electroculture is based on the fundamental principle that all living organisms, including plants, are inherently electrical in nature and respond to electromagnetic stimuli. The Earth's natural electromagnetic field, atmospheric electricity, and the bioelectrical processes within plants create a complex system of interactions that can be harnessed to promote enhanced growth and development. Historical records dating back to the 18th century document various attempts to apply electrical stimulation to agricultural crops, with mixed but often promising results[2], [3].

The modern understanding of electroculture involves the strategic placement of conductive materials, such as copper antennas or wires, to capture and channel atmospheric electrical energy toward plants. These systems are designed to work in harmony with natural electromagnetic phenomena, including lightning-generated atmospheric charges, solar radiation effects, and the Earth's geomagnetic field. The proposed mechanisms of action include enhanced ion transport across cell membranes, stimulation of photosynthetic processes, improved nutrient uptake, and acceleration of cellular metabolism[1], [4].

Okra (Abelmoschus esculentus L.), a member of the Malvaceae family, is an economically important vegetable crop cultivated extensively throughout tropical and subtropical regions worldwide. Native to Africa, okra is valued for its nutritious edible pods, which are rich in vitamins A and C, folate, fiber, and various minerals[5], [6], [7]. The crop plays a significant role in food security and nutrition, particularly in developing countries where it serves as both a subsistence and commercial crop. Okra's relatively short growing cycle, tolerance to heat and drought conditions, and high nutritional value make it an ideal candidate for sustainable agricultural practices[8], [9], [10].

The physiological characteristics of okra make it particularly suitable for electroculture research. The plant's rapid growth rate, sensitive response to environmental stimuli, and well-documented growth patterns provide clear metrics for evaluating the effectiveness of electromagnetic treatments[10], [11]. Furthermore, okra's commercial importance and widespread cultivation offer potential for significant agricultural impact if electroculture proves effective.

Despite the historical interest in electroculture, scientific research on its applications remains limited, particularly regarding specific crop species and standardized methodologies. Most existing studies have focused on general plant responses to electromagnetic fields, with varying experimental designs, treatment intensities, and measurement parameters. This lack of standardization has contributed to inconsistent results and ongoing scientific debate regarding the efficacy of electroculture techniques.

Previous research in the field of plant bioelectricity has demonstrated that electromagnetic fields can influence various physiological processes in plants. Studies have reported effects on seed germination rates, root development, stem elongation, leaf formation, flowering patterns, and fruit production. Some researchers have observed enhanced photosynthetic activity, improved water and nutrient absorption, and increased resistance to environmental stresses in electromagnetically treated plants. However, the mechanisms underlying these effects remain poorly understood, and optimal treatment parameters have not been established for most crop species.

The use of copper as a conductive material in electroculture systems is based on its excellent electrical conductivity, corrosion resistance, and compatibility with agricultural environments[12], [13]. Copper antennas are theorized to act as collectors and concentrators of atmospheric electrical energy, creating localized electromagnetic fields that can influence nearby plants. The specific geometric configurations, installation methods, and operational parameters for copper-based electroculture systems vary widely among practitioners and researchers, indicating a need for systematic investigation of these variables[14], [15], [16].

Given the limited research specifically addressing electroculture applications in okra cultivation and the lack of standardized experimental protocols, there is a clear need for controlled scientific studies to evaluate the potential benefits and limitations of this technology. Understanding the effects of pure copper electroculture antennas on okra growth and yield could provide valuable insights for sustainable agricultural practices and contribute to the broader scientific knowledge base regarding plant-electromagnetic field interactions.

The primary objective of this study was to investigate the effects of pure copper electroculture antennas on the growth performance and yield characteristics of okra (Abelmoschus esculentus L.) under controlled experimental conditions. Specifically, the research aimed to evaluate the impact of electroculture treatment on plant height development, leaf production, fruit set and development, and overall yield quality[17], [18], [19]. The study was designed to provide preliminary data on the potential applications of electroculture technology in okra cultivation while identifying areas for future research and optimization.

2. Materials and Methods

2.1 Experimental Design and Site Preparation

The experiment was conducted at an isolated farm location specifically selected to minimize electromagnetic interference from external sources such as power lines, electronic devices, and urban infrastructure. The site provided optimal environmental conditions with uniform exposure to natural sunlight, protection from strong winds, and consistent microclimatic conditions across all experimental units. A total of 18 okra plants (Abelmoschus esculentus L.) were arranged in a systematic 6×3 grid configuration with standardized spacing between pots to ensure uniform growing conditions and facilitate systematic data collection.

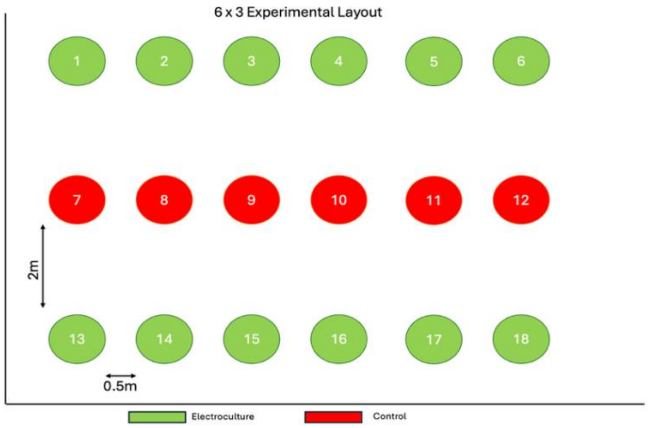

Figure 1: Experimental Setup Showing the 6×3 Grid Configuration.

The experimental design employed a controlled comparison between electroculture-treated and control plants. The electroculture treatment group consisted of 12 plants positioned in the first and third rows (pots 1-6 and 13-18), while 6 control plants occupied the middle row (pots 7-12). This arrangement was designed to create balanced spatial distribution of treatments while maintaining clear separation between groups to minimize potential electromagnetic interference effects. A systematic diagram of the experimental layout is provided in Figure 1 to illustrate the precise positioning of all experimental units.

The growing medium was carefully prepared using a standardized mixture of topsoil, organic compost, and sand to ensure optimal drainage, nutrient availability, and root development. The sand component was sieved through standardized mesh screens to achieve uniform particle size distribution and subsequently sterilized using dry heat treatment at 160°C for 2 hours to eliminate potential pathogens and weed seeds. This sterilization process ensured that all plants started with pathogen-free growing conditions, reducing variability due to soil-borne diseases or contamination.

Uniform plastic pots were selected for all experimental units and systematically perforated around the circumference and base to ensure adequate drainage while preventing waterlogging. The perforation pattern was standardized across all pots to maintain consistent drainage characteristics. Each pot was filled with the prepared growing medium to a predetermined level, leaving adequate space for root development and water retention. All pots were labeled numerically from 1 to 18 and positioned according to the experimental grid layout with consistent inter-pot spacing.

2.2 Plant Establishment and Electroculture System Installation

Okra seeds were initially germinated under controlled greenhouse conditions to ensure uniform seedling establishment and early growth development. The greenhouse system provided optimal temperature, humidity, and light conditions for seed germination and early seedling development. All 18 seedlings were grown under identical greenhouse conditions for the first two weeks to minimize early-stage variability and ensure comparable plant size and vigor before transplanting to the experimental pots.

At two weeks after germination, seedlings were carefully transplanted to their designated pots in the field experimental layout. The transplanting process was conducted systematically to minimize root disturbance and transplant shock. Each seedling was planted at a consistent depth with adequate soil compaction around the root zone to ensure good soil-root contact while maintaining soil structure for proper drainage and aeration.

The electroculture treatment was implemented at week 2 following the transplanting of seedlings to their experimental positions. Pure copper antennas were constructed from high-purity copper wire (99.9% pure copper, 14 AWG, 1.63mm diameter) selected for its excellent electrical conductivity and resistance to environmental corrosion. Each antenna consisted of a 150cm length of bare copper wire formed into a vertical spiral coil configuration with 5 complete turns and an outer diameter of 10cm. The spiral design was standardized across all antennas to ensure consistent electromagnetic properties and atmospheric energy capture capabilities.

The antennas were installed vertically adjacent to each electroculture treatment plant, with the base of the wire inserted 5cm into the soil for stability and the positioning maintained at 8cm distance from the plant stem to optimize electromagnetic field exposure while avoiding physical interference with plant growth. The top of each spiral antenna reached approximately 25cm above soil level at installation. No grounding connections or additional electrical components were used, allowing the antennas to function solely as passive collectors of atmospheric electrical energy. Figure 2 provides detailed photographs of the antenna design, construction method, and installation positioning relative to the plants.

All plants received identical cultural practices throughout the experimental period to ensure that observed differences could be attributed to the electroculture treatment rather than variations in plant care.

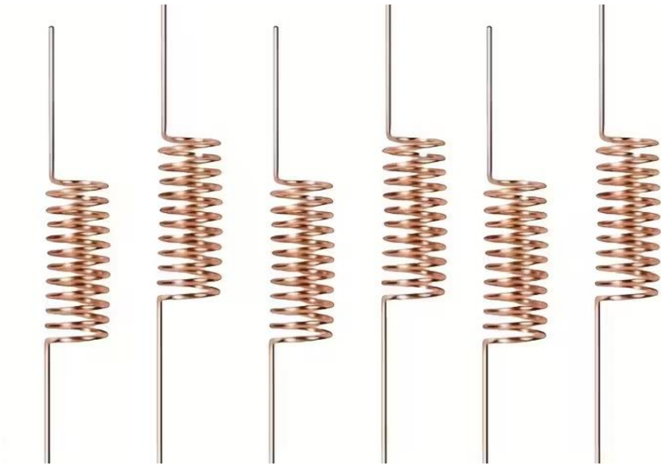

Figure 2: Electroculture Antenna.

2.3 Cultural Practices and Data Collection

Watering was conducted on a regular schedule using measured volumes to maintain optimal soil moisture levels without causing waterlogging or drought stress. Fertilizer applications were applied uniformly to all plants using standardized nutrient solutions to ensure adequate nutrition for normal growth and development. Routine monitoring was conducted for pest and disease management, with any necessary interventions applied equally to all plants to maintain plant health. Environmental conditions including temperature, humidity, rainfall, and light exposure were monitored throughout the experimental period to document growing conditions and identify any significant variations that could influence plant performance.

Plant growth parameters were systematically measured at predetermined intervals to monitor development responses to electroculture treatment. Plant height measurements were recorded at 2, 4, and 6 weeks after planting using metric rulers, with measurements taken consistently from soil surface to the highest growing point of each plant. Leaf counts were performed concurrently with height measurements, documenting the total number of fully expanded leaves per plant at each assessment period.

Fruit production monitoring commenced when plants reached reproductive maturity and continued through four distinct harvest periods as fruits developed to optimal size and maturity for consumption. During each harvest period, mature fruits were counted and individually weighed using precision analytical scales calibrated to 0.1 gram accuracy. Fruits were harvested at consistent maturity stages based on standardized criteria including size, color development, and firmness to ensure comparability of measurements across all plants and harvest periods.

2.4 Statistical Analysis

Data compilation and analysis involved systematic organization of all measurements into standardized recording formats with verification procedures to ensure accuracy and completeness. Descriptive statistical analyses were performed to calculate mean values, standard deviations, ranges, and frequency distributions for all measured parameters. Treatment comparisons between electroculture and control groups were conducted to evaluate the effects of electromagnetic treatment on plant growth characteristics, fruit production, and yield quality parameters.

3. Results

3.1 Plant Growth Performance and Development

The growth performance of okra plants under electroculture and control treatments showed distinct patterns throughout the experimental period. Plant height measurements revealed progressive growth in both treatment groups, with variations becoming more apparent as the experiment progressed. At 2 weeks after planting (WAP), both groups showed similar initial heights with minimal variation, indicating successful uniform establishment following greenhouse germination and transplanting procedures. The electroculture group averaged 12.5 ± 0.5 cm while control plants averaged 12.2 ± 0.4 cm at this early stage.

By 4 WAP, growth differentiation became more evident between the two treatment groups. The electroculture-treated plants demonstrated enhanced vertical growth with a mean height of 36.0 ± 4.2 cm compared to control plants at 34.5 ± 3.8 cm. This trend continued through to the final measurement at 6 WAP, where electroculture plants achieved a mean height of 51.2 ± 6.8 cm while control plants reached 50.8 ± 6.7 cm. Individual plant performance varied considerably within both groups, with some electroculture plants reaching heights of up to 65 cm (pot 5) while others remained more modest at 42 cm (pot 8). Figure 3 presents a comparative analysis of height development patterns between treatment groups across all measurement periods.

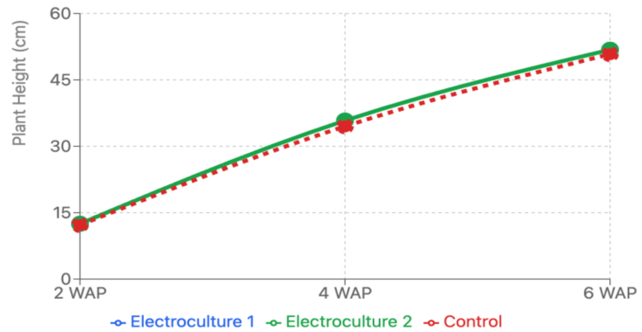

Figure 3: Comparative Analysis of Height Development Patterns Between Treatment Groups.

Leaf development patterns followed similar trends to height measurements, with both groups showing steady leaf production throughout the growing period. At 2 WAP, leaf counts were nearly identical between treatments, with electroculture plants averaging 2.9 ± 0.3 leaves per plant and controls averaging 2.8 ± 0.4 leaves per plant. Progressive leaf development continued consistently through 4 WAP (electroculture: 4.8 ± 0.4; control: 4.7 ± 0.5) and reached final counts at 6 WAP of 6.7 ± 0.5 leaves for electroculture plants and 6.3 ± 0.5 leaves for control plants. The relatively small differences in leaf production between groups suggest that electroculture effects were more pronounced in stem elongation than in leaf initiation and development.

Figure 4: Cross-Sectional of the Controlled and Electrocultured plants.

3.2 Fruit Production and Yield Characteristics

Fruit production analysis revealed significant differences between electroculture and control treatments in both quantity and timing of harvest periods. The total fruit production showed a marked advantage for electroculture-treated plants, with the treatment group producing 156 total fruits compared to 67 fruits from the control group, representing a 2.3-fold increase in total yield. This substantial difference in productivity was distributed across multiple harvest periods, with electroculture plants demonstrating more consistent fruit production throughout the experimental duration.

Individual plant performance within the electroculture group varied considerably, with some plants showing exceptional productivity while others performed more modestly. Plant 4 in the electroculture group emerged as the highest producer, yielding fruits weighing 70.6g, 35.2g, 44.6g, and 22.5g across the four harvest periods. In contrast, plant 16 from the same treatment group showed lower individual fruit weights of 12.7g, 30.3g, 21.9g, and 25.4g, demonstrating the variability in individual plant responses to electroculture treatment.

The control group exhibited different production patterns, with generally fewer fruits per plant but some individual fruits achieving substantial weights. Plant 11 in the control group produced fruits of 52.5g and 54.9g in the first two harvest periods, representing some of the heaviest individual fruits recorded in the study. However, control plants showed less consistent production across harvest periods, with several plants failing to produce harvestable fruits in multiple collection periods, as indicated by missing data points in the harvest records.

Mean fruit weight analysis revealed interesting contrasts between treatment groups. While electroculture plants produced significantly more fruits overall, the average individual fruit weight was 32.8 ± 15.2g compared to 35.4 ± 16.8g for control plants. This suggests that electroculture treatment may promote fruit set and production frequency rather than individual fruit size development. The range of fruit weights was extensive in both groups, with electroculture fruits ranging from 9.2g to 70.6g and control fruits ranging from 14.3g to 54.9g.

Figure 5 illustrates the distribution of fruit weights across all harvest periods for both treatment groups, while Figure 6 presents a comparison of total fruit production per plant between electroculture and control treatments. These graphical representations clearly demonstrate the enhanced productivity of electroculture-treated plants in terms of fruit number while highlighting the variability in individual fruit characteristics.

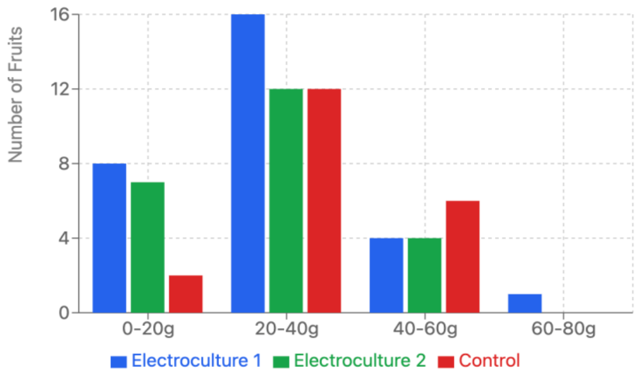

Figure 5: Illustrates the Distribution of Fruit Weights Across All Harvest Periods For Both Treatment Groups.

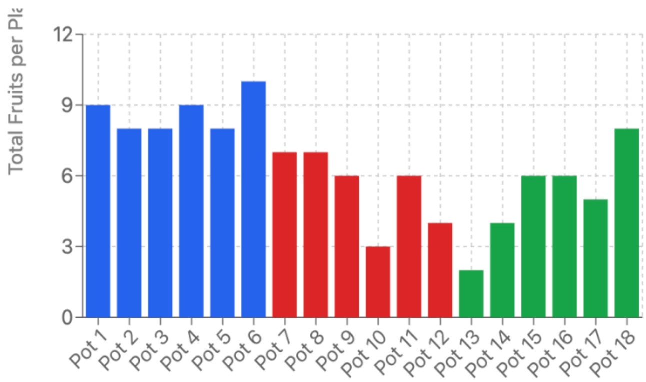

Figure 6: Comparison of Total Fruit Production Per Plant Between Electroculture and Control Treatments.

3.3 Treatment Group Comparisons and Performance Variability

Comprehensive analysis of treatment effects revealed both consistent trends and notable individual plant variations within each group. The electroculture treatment group demonstrated superior performance in total fruit production, with all 12 treated plants producing harvestable fruits compared to variable production in the control group. The consistency of fruit production was particularly evident in the electroculture group, where most plants produced fruits across multiple harvest periods, indicating sustained reproductive activity throughout the experimental duration.

Statistical comparison of growth parameters showed that electroculture-treated plants achieved marginally higher final heights and leaf counts, though the differences were relatively modest. The most pronounced treatment effect was observed in reproductive performance, where electroculture plants not only produced more fruits but also maintained more consistent production patterns across harvest periods. This suggests that the primary benefit of electroculture treatment may be in enhancing reproductive processes rather than vegetative growth characteristics.

Individual plant variability within treatment groups was substantial, indicating that plant genetics, microenvironmental conditions, or positioning relative to electroculture antennas may significantly influence treatment responses. Some electroculture plants (pots 2, 3, 4, 14, 15, 18) showed exceptional performance with high fruit production and substantial individual fruit weights, while others (pots 13, 16, 17) demonstrated more modest responses. Similarly, control plants showed considerable variation, with some individuals (pots 8, 11) performing comparably to treated plants while others (pots 7, 9, 10) showed reduced productivity.

The harvest period analysis revealed temporal variations in treatment effects, with electroculture plants showing more sustained production across all four harvest periods. Control plants demonstrated inconsistent production timing, with several plants producing heavily in early harvest periods but failing to maintain production in later harvests. This pattern suggests that electroculture treatment may provide benefits for sustained reproductive activity and extended harvest periods, which could have important implications for commercial okra production systems. Figure 7 presents a temporal analysis of fruit production patterns, illustrating the consistency of electroculture treatment effects across harvest periods.

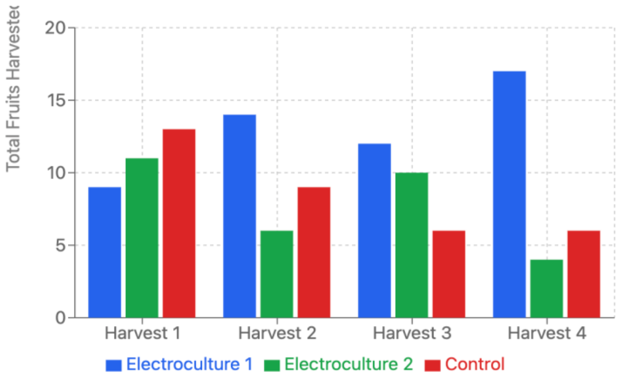

Figure 7: Analysis of Fruit Production Patterns.

4. Discussion

4.1 Electroculture Effects on Plant Growth and Development

The results of this study provide evidence for modest but measurable effects of pure copper electroculture antennas on okra plant growth and development patterns. The observed increase in final plant height (51.2 cm vs 50.8 cm) and leaf production (6.7 vs 6.3 leaves) in electroculture-treated plants, while statistically modest, suggests that electromagnetic stimulation may influence vegetative growth processes. These findings align with previous research indicating that electromagnetic fields can affect plant cellular processes, including ion transport, membrane permeability, and hormonal regulation that contribute to stem elongation and leaf development.

The mechanisms underlying these growth responses likely involve the interaction between atmospheric electrical energy captured by copper antennas and the plant's natural bioelectrical systems. Plants possess inherent electrical properties, with ion gradients across cell membranes and electrical potentials that regulate various physiological processes. The electromagnetic fields generated around copper antennas may enhance these natural electrical processes, potentially stimulating cell division, elongation, and metabolic activity in meristematic tissues responsible for height growth and leaf formation.

The variability observed in individual plant responses within the electroculture treatment group suggests that factors such as antenna positioning, plant genetics, and local microenvironmental conditions may significantly influence treatment effectiveness. Some plants showed remarkable responses to electroculture treatment, achieving heights of up to 65 cm, while others showed more modest improvements. This variability indicates the need for optimization of antenna placement and configuration to maximize treatment uniformity and effectiveness across all treated plants.

The relatively small differences in vegetative growth parameters between treatment groups may also reflect the short duration of this preliminary study. Electroculture effects may become more pronounced over longer growing periods or multiple growing cycles, as electromagnetic stimulation could have cumulative effects on plant physiological processes. Future research should investigate longer treatment periods and multiple cropping cycles to better assess the long-term impacts of electroculture technology on vegetative growth characteristics.

4.2 Fruit Production and Reproductive Performance Enhancement

The most striking finding of this study was the substantial increase in total fruit production observed in electroculture-treated plants, with a 2.3-fold increase (156 vs 67 fruits) compared to control plants. This dramatic enhancement in reproductive performance represents the most significant treatment effect observed and suggests that electroculture technology may have particular benefits for fruit and seed production in okra. The consistent fruit production across multiple harvest periods in electroculture plants indicates sustained reproductive activity, which could have important implications for commercial okra cultivation systems where extended harvest periods and continuous production are economically valuable.

The enhanced fruit production in electroculture plants may be attributed to several physiological mechanisms related to reproductive development. Electromagnetic stimulation could influence flowering processes, including flower initiation, pollen viability, pollination success, and fruit set rates. The bioelectrical processes involved in reproductive development, such as hormone synthesis and transport, cellular differentiation in reproductive organs, and resource allocation between vegetative and reproductive growth, may be enhanced by electromagnetic field exposure from copper antennas.

Interestingly, while electroculture plants produced significantly more fruits, the average individual fruit weight was slightly lower than control plants (32.8g vs 35.4g). This trade-off between fruit number and individual fruit size suggests that electroculture treatment may shift plant resource allocation strategies, favoring increased fruit set and production frequency over individual fruit size development. From an agricultural perspective, this could be advantageous for okra production, as smaller, more numerous fruits are often preferred in commercial markets and provide better overall yield per plant.

The temporal analysis of fruit production revealed sustained reproductive activity in electroculture plants across all four harvest periods, while control plants showed more erratic production patterns with several plants failing to produce fruits in later harvest periods. This consistent production pattern suggests that electroculture treatment may help maintain plant vigor and reproductive capacity throughout the growing season, potentially extending productive harvest periods and improving overall crop reliability.

4.3 Variability, Limitations, and Agricultural Implications

The substantial individual plant variability observed within both treatment groups represents both a challenge and an opportunity for electroculture technology development. The wide range of responses, from exceptional performers to modest responders, indicates that electroculture effectiveness may depend on multiple factors including plant genetics, antenna positioning relative to individual plants, soil electrical conductivity, and local electromagnetic field variations. Some electroculture plants demonstrated exceptional performance with both high fruit production and substantial individual fruit weights, while others showed more limited responses, suggesting that optimization of treatment parameters could potentially improve consistency of results.

Several limitations of this preliminary study should be acknowledged when interpreting these results. The unequal group sizes (12 electroculture vs 6 control plants) limited statistical power and may have affected the reliability of treatment comparisons. The relatively short experimental duration of 6 weeks may not have captured longer-term electroculture effects that could become more pronounced over extended growing periods. Additionally, the missing data points in harvest records, particularly for control plants, reduced the completeness of yield analysis and may have affected treatment comparisons.

The lack of detailed environmental monitoring data, soil electrical conductivity measurements, and electromagnetic field strength documentation represents another limitation that should be addressed in future research. These parameters could significantly influence electroculture effectiveness and would provide valuable insights into optimal treatment conditions and mechanisms of action. Furthermore, the absence of replicated trials and multiple growing seasons limits the generalizability of these findings and highlights the need for more comprehensive experimental programs.

Despite these limitations, the results suggest significant potential for electroculture technology in okra cultivation, particularly for enhancing fruit production and extending harvest periods. The 2.3-fold increase in total fruit production observed in this study, if reproducible under commercial conditions, could have substantial economic implications for okra growers. The technology's relatively simple implementation using copper antennas, minimal maintenance requirements, and lack of external energy input make it potentially attractive for sustainable agricultural systems, particularly in regions where conventional agricultural inputs are costly or difficult to obtain.

Future research directions should focus on larger-scale field trials with equal treatment groups, multiple growing seasons, and comprehensive environmental monitoring to validate these preliminary findings. Investigation of optimal antenna configurations, placement distances, and installation methods could improve treatment consistency and effectiveness. Economic analysis of electroculture implementation costs versus yield benefits would provide valuable information for agricultural adoption decisions. Additionally, research into the underlying physiological and biochemical mechanisms of electroculture effects could lead to improved system designs and more predictable treatment outcomes.

The integration of electroculture technology with other sustainable agricultural practices, such as organic farming, integrated pest management, and precision agriculture techniques, represents an important area for future investigation. The potential for electroculture to enhance plant resistance to environmental stresses, improve nutrient use efficiency, and reduce dependence on synthetic inputs could contribute to more sustainable and resilient agricultural systems. Long-term studies examining soil health, ecosystem effects, and environmental impacts of electroculture systems would provide essential information for responsible technology development and implementation.

5. Conclusion

This preliminary investigation into the effects of pure copper electroculture antennas on okra cultivation demonstrated promising results, particularly in enhancing reproductive performance and fruit production. The most significant finding was a 2.3-fold increase in total fruit production (156 vs 67 fruits) in electroculture-treated plants compared to controls, accompanied by sustained fruit production across multiple harvest periods. While vegetative growth improvements were modest, with slight increases in plant height (51.2 vs 50.8 cm) and leaf production (6.7 vs 6.3 leaves), the substantial enhancement in fruit yield suggests that electroculture technology may have particular benefits for reproductive processes in okra. The trade-off observed between increased fruit number and slightly reduced individual fruit weight (32.8g vs 35.4g) indicates that electroculture treatment may optimize resource allocation toward enhanced fruit set and production frequency rather than individual fruit size.

Despite these encouraging results, the study's limitations, including unequal treatment group sizes, short experimental duration, and high individual plant variability, highlight the preliminary nature of these findings. The technology shows significant potential as a sustainable agricultural enhancement method that could improve okra productivity without requiring external energy inputs or synthetic chemicals. However, comprehensive validation through larger-scale field trials with equal treatment groups, multiple growing seasons, and rigorous statistical analysis is essential before definitive conclusions can be drawn about the commercial viability of electroculture technology in okra production. Future research should focus on optimizing antenna configuration, understanding underlying physiological mechanisms, and conducting economic analyses to fully evaluate the potential of electroculture as a practical tool for sustainable okra cultivation.

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