Scientific Papers. Series B, Horticulture. Vol. LXIX, No. 2, 2025
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

# STUDY ON THE IMPACT OF ELECTROMAGNETIC FIELDS ON THE GROWTH AND DEVELOPMENT OF CERTAIN VEGETABLE PLANT SPECIES

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***Abstract***

*Electromagnetic fields can influence plant growth and development, with their effects depending on frequency, intensity, and exposure duration. Research conducted so far has highlighted both positive and negative effects. Regarding the beneficial effects, exposure to low-frequency fields has been associated with faster seed germination, stimulation of stem and root growth, and increased biomass accumulation. Additionally, these fields can activate metabolic processes by increasing the levels of plant hormones (auxins, gibberellins) and improving enzymatic activity, supporting the overall health of plants. On the other hand, prolonged or intense exposure can lead to negative effects, such as oxidative stress caused by an excess of reactive oxygen species (ROS), which can damage cells. Some studies show growth inhibition, manifested by reduced root and stem length, as well as a decrease in chlorophyll content, which affects photosynthetic efficiency. The aim of this study is to analyze the impact of different wavelengths on the growth of vegetable plants, in order to identify optimal electromagnetic conditions that could enhance agricultural productivity and reduce associated risks.*

***Key words****: electromagnetic fields, seeds, germination.*

## INTRODUCTION

The study of the impact of electromagnetic fields on the growth and development of certain species of vegetable plants is a topical and highly interesting topic in the context of increasing exposure to electromagnetic radiation from various sources. The results of existing research indicate that these fields can have variable effects on plants, influencing essential physiological processes, such as seed germination, root growth, plant growth, photosynthesis, and water and nutrient absorption.

These physical methods are ecological and influence the physiological and biochemical processes of rice seeds (Carbonell et al., 2000) and onion García et al. (2002) leading to faster germination and improved plant development.

Some studies have shown positive effects, such as stimulating growth and biomaterial production, while others have reported inhibitions, oxidative stress and changes in plant cell structure (Iderawumi & Friday, 2020). Maffei (2014) and Pawełek et al. (2022) state that exposure of seeds and plants to static magnetic fields and non-ionizing electromagnetic fields showed positive effects on germination, growth rate, stress resistance and yield.

## MATERIALS AND METHODS

The study analyzes the influence of electromagnetic fields on seed germination. It examines the impact of magnetic fields on seed germination, plant growth, and fruiting.

## RESULTS AND DISCUSSIONS

Shabrangy et al. (2021) and Shabrangy (2024) investigated methods for using different magnetic fields to improve seed germination, plant growth, and yield. They specify that these methods include magnetic fields weaker than the geomagnetic field, reversed magnetic fields, strong static magnetic fields, electromagnetic fields, magnetized water, and high-gradient magnetic fields.

The effect of the electromagnetic field on seed germination. has been noted by numerous researchers. Etimad et al. (2022) mentions in their study that magnetized water, obtained by passing it through a special magnet, can stimulate plant growth and productivity. It also improves germination, vegetative development, nutrient absorption and photosynthesis, while reducing soil salinity. At the same time, they conclude that the electromagnetic field can transform poor quality water into a useful resource.

Naz et al. (2012) stated that the effect of pre-planting magnetic treatments on germination, growth and yield of okra (*Abelmoschus esculentus* cv. Sapz paid) by exposure to a magnetic field of 99 mT for 3 and 11 minutes led to a significant increase ($P < 0.05$) in germination, number of flowers, leaf area, plant height, number of fruits and seeds, and fruit mass per plant. They concluded that exposure to the value of 99 mT for 11 minutes had the best results compared to the control.

Experiments conducted to see the influence of electromagnetic field intensity on okra seed germination indicated that both the seed exposure time and the electromagnetic field frequency had a favorable effect on germination time and the percentage of germinated seeds (Rachieru et al., 2022).

Antonova-Karacheva (2021) based on the results obtained showed a positive effect obtained in seeds treated with a voltage of 6 kV, exposure of 20 seconds and an interval of 8 days until sowing.

Ziaf et al. (2022) claim that treatment of okra seeds with 100 mT magnetic fields for 20 minutes improved germination, growth and plant yield. Also, priming of seeds in 1% KNO3 solutions increased chlorophyll content and photosynthetic efficiency. These methods can increase the efficiency of agricultural production.

Souza Torres et al. (1999) exposed tomato seeds of cv. Campbell 28 to magnetic field values of 0.08, 0.10 or 0.17 Tesla for 1-25 minutes. 18 variants of the 21 treatments showed an improvement in germination after 5 days, and 10 variants after 7 days. They noted that the growth of seedlings was 5-25% in the case of 12 treatments, the best result being obtained with 0.10 T for 10 minutes. It was found that 16 treatments favored the increase in root length.

The study by Charles et al. (2021) aimed to investigate the effects of microwaved water on the growth of tomato seedlings (*Lycopersicon esculentum*). They used three variants: seeds and plants treated with tap water, boiled and cooled water, and microwaved water, for 5 weeks. The results showed that both boiled and microwaved water stimulated stem growth, with the greatest positive effect observed for boiled water. This study suggests that microwave radiation did not have a negative impact on plants and that the use of microwave appliances does not negatively affect the heated substances or human health.

Peteiro-Cartelle and Cabezas-Cerrato (2009) analyzed the influence of static magnetic fields on mitosis in *Allium cepa*. They found that the magnetic field did not modify the mitotic index, but increased the prophase and metaphase indices, while decreasing those of anaphase and telophase. An increase in the rate of cell emergence was also observed, and cytogenetic effects were minimal. The results indicated a shortening of the duration of anaphase-telophase under the influence of the magnetic field.

Jeong et al. (2024) found that the application of a directed electromagnetic field stimulated the germination and growth of radish plants.

Katsenios et al. (2021) in an experiment conducted on kale and spinach seeds exposed to a pulsed electromagnetic field at three growth stages found that some treatments increased plant weight, positively influencing growth characteristics.

Exposure of radish seeds to stationary magnetic fields stimulated germination and vigor, with optimal effect at 20 mT for 12 minutes, while the variable field for 12 minutes had a negative impact (Konefał-Janocha et al., 2019).

Kaigorodova et al. (2021) in their experimental work showed that in the ranges of 5-440 B/m (electric) and 0-0.53 μT (magnetic), the electromagnetic field stimulated the growth of beans, increasing chlorophyll (15-65%), polyphenols (17%), antioxidant activity (1-15%) and ascorbic acid (12-28%). They observed a reduction in carotene at 60-100 B/m and the lack of correlation between pigments and antioxidant activity at technical maturity.

Applying an 88 mT magnetic field in a sequencing batch reactor enhanced biomass aggregation (75.0-95.2%) compared to the control (65.5%), reducing sludge volume index (25.8 ml/g vs. 73.1 ml/g) and improving COD and ammonia-nitrogen removal. This suggests that magnetic fields can mitigate sludge bulking and enhance pollutant removal efficiency (Zaidi et al., 2022).

Krylov and Tarakonova (1960) discovered the effects of magnetic fields on plants, suggesting an auxin-like effect called magnetotropism. Boe and Salunkhe (1963) associated it with tomato ripening. It was found that roots respond more to magnetic fields than to light, and species-specific factors are essential for the manifestation of tropism (Pittman, 1962).

Haq et al. (2012) reported a reduction in germination time under different magnetic field intensities, both under alternating current (AC) and direct current (DC) conditions. They observed a significant decrease in germination time only at 110 mT for 10 minutes.

Shine et al. (2011) conducted experiments on soybean seeds (Glycine max) using static magnetic fields and found that germination, seedling growth and biomass were improved, with the results being maximal at 200 mT (60 min) and 150 mT (60 min). These treatments increased photosynthetic efficiency and leaf protein content, demonstrating significant benefits for plant growth.

Moon and Chung (2000) cited by Iderawumi and Friday (2020) state that treating tomato seeds with AC electric fields with intensities ranging from 4 to 12 kV/cm and AC magnetic flux densities ranging from 3 to 1000 G for 15 to 60 seconds accelerated the germination rate by approximately 1.1-2.8 times compared to untreated seeds. However, an inhibitory effect on germination was observed when the electric field exceeded 12 kV/cm or the exposure time was greater than 60 seconds.

Studies by Mukhammadiev et al. (2022) have shown that electrical stimulation of potato tubers before planting can accelerate shoot emergence by 3-4 days, depending on the variety. Electrically stimulated plants also showed more vigorous growth, being 4-5 cm taller and having a greater number of stems. In a second experiment, each electrically stimulated bush produced an average of 813 grams of tubers, compared to 398 grams in the control group. Visual and serological analyses indicated that electrical stimulation reduced viral infections in plants. For example, the Kuvonch-1656M variety showed an infection rate of 12% in the studied variant, compared to 16% in the control variant, and latent viral infections were 26% and 31%, respectively.

Corey et al., (2013) mention that plants produce a variety of hormones that regulate growth, development and response to environmental stress. In addition to the perception and signaling of these molecules, the enzymes that control their dosage and activity are also essential. The scientific study explores the role of enzyme families, such as SABATH methyltransferases, methylesterases, GH3 acyl acid-amido synthetases and peptide hydrolases, in the biosynthesis and modification of hormones, contributing to the chemical signaling network that supports plant adaptation.

Etimad Alattar, Eqbal Radwan (2020) conducted a study investigating the effect of water treated with radiofrequency electromagnetic radiation on the growth of pepper plants (*Capsicum annuum*). The plants were divided into two groups: one watered with water exposed to radiation from a Wi-Fi router for one hour per day and one with tap water (control). The results showed that the treatment had a negative impact on growth, causing a reduction in shoot length, stem diameter, root length and plant health index. There were also decreases in the number of leaves, flowers, fruits and seeds, as well as a significant delay in flowering.

Ramezani et al. (2012) in their study stated that electromagnetic radiation can be a stress factor for plant development, influencing metabolism, gene expression and growth. The effects occurred both in directly exposed and adjacent tissues, being influenced by root characteristics and plant condition. 14.3 Hz magnetic fields can protect plants from drought, delaying harmful changes in transpiration and photosynthesis. Under normal conditions, no significant effects were observed, except for a decrease in relative transpiration.

Sincak et al. (2023), in their study affirms that the electromagnetic fields offer a promising method for controlling biotechnological processes, influencing cell growth and metabolism without altering the culture medium or the resulting products. The analysis of 103 experimental and theoretical studies highlighted beneficial effects such as accelerated microbial growth, stabilization of bacterial communities in wastewater treatment, improved fermentation, and enhanced metal bioleaching. Although these applications are promising and sustainable, the use of magnetic fields in biotechnology remains largely unexplored.

Nagy and Fischl (2004) reported that a static magnetic field (0.1-1 mT) reduced fungal colony growth by 10%, with significant effects at 0.1 mT (P = .001). Conidia production increased (68–133%) in *Alternaria alternata* and *Curvularia inaequalis*, but decreased (79-83%) in *Fusarium oxysporum*, with generally significant deviations (P = 0.05).

Magnetic treatment of irrigation water improved productivity and water savings for eggplant, faba beans, and tomatoes, reducing soil pH and increasing crop yield. Water savings ranged from 11% to 14.2%, and profitability increased significantly (Nessrien, 2018).

Basant and Harsharn Singh (2009) conducted a study on the magnetic treatment of different types of irrigation water and its impact on the productivity of snow pea, celery, and green pea plants. The experiments were carried out in greenhouses using potable water, recycled water, and saline water treated magnetically. The results showed significant increases in yield and productivity for celery and green peas, particularly when recycled water and 3000 ppm saline water were used. However, no positive effects were observed on pea plants. Additionally, the magnetic treatment of water had an impact on the soil, reducing pH and increasing electrical conductivity and available phosphorus in the soil for celery and green peas.

## CONCLUSIONS

Exposure to electromagnetic fields positively influences the growth rate of vegetable species, leading to greater height, leaf area, and biomass accumulation.

Seeds subjected to electromagnetic field treatment had higher germination rates and sprouted more quickly compared to untreated seeds.

Crop yield increase. Exposure to electromagnetic fields resulted in higher yields, with significant improvements in the size, weight, and productivity of the fruits.

Regarding water and nutrient absorption, it was found that treated plants showed higher efficiency in absorbing water and nutrients, contributing to better resistance to environmental stress.

Studies revealed certain physiological changes, including increased enzyme activity, chlorophyll content, and photosynthesis rates, suggesting enhanced metabolic activity under the influence of electromagnetic fields of certain intensities.

Regarding species-specific responses, it was found that the effects varied depending on the vegetable species, with some plants responding more positively than others.

Scientific results suggest that controlled exposure to electromagnetic fields could be a promising technique for improving vegetable production while reducing resource inputs.

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