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Effects Of Radio Frequency Radiation On Growth Of Groundnut Around Mobile Base Transmitter Stations

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Abstract
Electromagnetic radiation, specifically radiofrequency electromagnetic fields (RF-EMFs), has become a ubiquitous aspect of modern life, with frequencies ranging from 10 MHz to 300 GHz in the electromagnetic spectrum. Cell phone technology operates within this range, utilizing frequencies between 800 MHz and 3 GHz, while cell tower antennas emit pulsed low frequencies, commonly referred to as microwaves (300 MHz–300 GHz). According to the International Telecommunication Union (ITU), this widespread use of RF-EMFs leads to high concentrations of electromagnetic radiation in the environment. Plants, being immobile, are ideal subjects for investigating the effects of RF-EMF exposure, particularly in terms of thermal and non-thermal characteristics. This study focuses on the impact of RF-EMF exposure from mobile base transmitter stations (GSM Masts) on the growth of groundnut plants. Two varieties of groundnut seeds were used, divided into control and experimental groups. The weight and length of the plants were recorded at regular intervals, and the days of flowering were observed and recorded. One-way ANOVA analysis revealed significant differences ($P<0.05$) in weight and length between the control and experimental groups. Exposure to RF-EMFs from GSM Masts resulted in slowed plant growth, adverse coloration changes, physiological and metabolic alterations, and genetic mutations, ultimately leading to plant death. This study concludes that radio-frequency radiation from GSM Masts has negative effects on groundnut plants, highlighting the importance of considering the potential environmental impacts of electromagnetic radiation.
***Keywords**: RF-EMF, electromagnetic fields, GSM Masts, Mobile base transmitter station, groundnut*

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I. Introduction

Over the past decade, cell phone usage has increased exponentially, with the global system for mobile communication (GSM) technology transmitting voice and data services through radiofrequency electromagnetic fields (RF-EMFs) in the range of 800-2400MHz (Yadav & Jha, 2023). Electromagnetic radiation, including RF-EMFs, consists of synchronized oscillations of electric and magnetic fields that travel through a vacuum at the speed of light (Phillips & Fritzsche, 2024). This radiation encompasses a wide range of frequencies, from high-energy cosmic rays and gamma rays to low-energy microwave radiation and radio waves (Foreword, 2022). Cell phones are the most widely used electromagnetic field (EMF) device globally, with an estimated 96.2% of the population using them (Guyon *et al.*, 2020).

The rapid growth in mobile phone usage has led to an increase in mobile base transmitter stations (GSM Masts) in urban and rural areas, resulting in adverse health effects due to RF-EMF radiation (Amponsah *et al.*, 2022). The World Health Organization (WHO) has classified RF radiation from cell phones as a "Possible Human Carcinogen" (Luo *et al.*, 2020). RF-EMFs also affect the plant system, altering physiological patterns, seed germination rates, root development, and biomass (Yadav & Jha, 2023; Tan *et al.*, 2023). Electromagnetic radiations cause changes in plants at the cellular and molecular level (Alattar & Radwan, 2020; Tan *et al.*, 2023), stimulating physiological, cytological, ultrastructural, and genetic modifications (Alattar & Radwan, 2020).

RF-EMFs primarily affect the cell membrane, influencing ion activation and dipole polarization in living cells (Matthew & Kazaure, 2021). Exposure to RF-EMFs affects plant development by influencing metabolic activities, gene expression, and growth-related aspects (Tan *et al.*, 2023; Duarte *et al.*, 2023), leading to changes in tissues directly subjected to radiation and adjacent tissues (Kul *et al.*, 2021). The responses elicited in different plant species depend on the physical parameters of the radiation source and the status of the biological material (Zandi & Schnug, 2022). RF-EMFs affect essential physiological processes in exposed plants, including respiration, photosynthetic pigments, photosynthesis, hormonal systems, antioxidant systems, mitotic division processes, and genetic regulation (Gudkov *et al.,* 2019; Ayesha *et al.,* 2023; Tang *et al.,* 2018; Dziwulska-Hunek *et al.,* 2020; Del Socorro *et al.,* 2023; Levitt *et al.,* 2022; Upadhyaya *et al.,* 2022; McGrath *et al.,* 2021).

Despite the effects of RF-EMFs on living organisms, knowledge about this issue is still insufficient (Belli & Indovina, 2020). Recent years have seen numerous reports on the effects of electromagnetic radiation on living systems, with both positive and negative effects (Kim *et al.,* 2021). While the effects of direct exposure to radiation on plant development and growth are well-documented, the effects of indirect exposure are less clear. This study aims to investigate the effects of exposure to RF-EMFs from mobile base transmitter stations (GSM Masts) on the growth of groundnut plants.

II. Materials And Methods

The current study was conducted over 36 days, from February to July 2020. The economic importance of groundnut plants to the food industry and agriculture led to their selection for study. Furthermore, this species is valued for its cultural and economic value in the area (Muhammad *et al.,* 2020).

Plant Selection and Treatment

The groundnut seeds used in this study were purchased from the Sabon Gari Market in Ogbomosho, Nigeria, a major hub for agricultural supplies. Two varieties of groundnut seeds, Kampala and SAMNUT 23, were selected for this experiment. A total of 500 seeds of each variety were purchased and divided into control (GROUP A) and exposed groups (GROUP B).

Experimental Design

Group A seeds were sown 3 per bowl at a depth of 3cm in perforated bowls filled with 3.00 kg of loamy soil. Group B seeds were sown at two distances from the transmitter station: 7.0104 meters (ICNIRP's recommended exposure limit) and 1250 meters (a typical distance between a GSM mast and surrounding vegetation). The seeds in Group B were exposed to radio-frequency radiation from a GSM mast with a transmission frequency of 900 MHz to 1800 MHz.

Plant Care and Data Collection

Weeding began 3 weeks after planting and was done carefully by hand to prevent damage to the plants. The experiment was carried out in an open area, and the plants were watered every morning with the same quantity of water for both groups. The fresh biomass weight of the plants was recorded every 6 days for 36 days, and the height of the plants was observed and recorded every two weeks. The days of flowering were also recorded.

Statistical Analysis

One-way ANOVA was used to analyze data obtained from weight and length results studies. A significance level of $P<0.05$ was used to determine significant differences between the groups.

III. Results And Discussion

The germination of seeds in the exposed group was observed five days after planting, while the control group germinated four days after sowing. At 25 days after sowing, the exposed group (Group B) flowered, while the control group (Group A) produced its first flower four days earlier. However, the second flowering of the control group started before the exposed group. By 50 days after sowing, many leaves in the exposed group had dried and turned yellow, significantly differing from the control group.

The germinating sprouts near the radio-frequency radiation from the GSM mast were shorter and weaker. After sixty days, plants at 7.0104 meters (ICNIRP's recommended exposure limit) away from the GSM mast had growth issues, despite no change in length. These plants also had reduced water intake, resulting in a significant weight difference between the control and exposed groups (Table 2). Groundnuts planted outside the radio-frequency radiation (Group A) appeared visually vital with a clear green color, while Group B was withered with less dense vegetation (Figure 1). The length of the experiment was also analyzed using a bar chart (Figure 2).

Table 1: Location for each group of GSM mast

Group	Location	Geo-cordinate	Radio-Frequency Radiation Level ($\mu W/m^2$)	Motivation for choice of location for each group
Control	Rehoboth Nursery and Primary School, Iwagba area, Ogbomoso, Nigeria	8º 9’ 4” N, 4º 14’ 6” E	47	Minimal exposure of radiation from GSM mast
Exposed	Close to Miracle clinic junction Iwagba area, Ogbomoso, Nigeria	8º 9’11” N, 4º 14’ 17” E	295.4	The GSM mast is very close to the uncompleted building

Table 2: Sample weight differences for groundnut plant (far field)

Day after Sowing	Sample A (Control)	Sample B (Exposed)	Weight difference
	Weight (kg)		
1	3.00	3.00	0.00
6	3.00	2.80	0.20
12	3.05	3.00	0.05
18	2.95	2.85	0.10
24	2.80	2.80	0.00

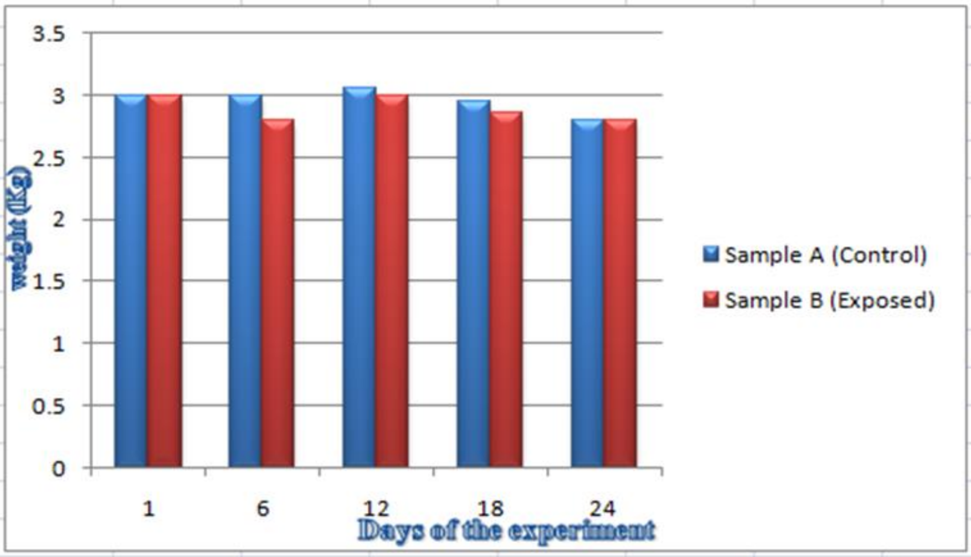

Fig. 1: Bar chart analysis of groundnut plant weight difference experiment (far field)

Table 3: Sample length differences for groundnut plant (near field)

Week of the experiment	Group A (Control)	Group B (Exposed)	Length difference
	Length (cm)		
2	8.50	5.00	3.50
4	16.50	10.00	6.50
6	19.50	12.00	7.50
8	23.00	15.00	8.00
10	26.50	20.00	6.50
12	30.00	24.00	6.00

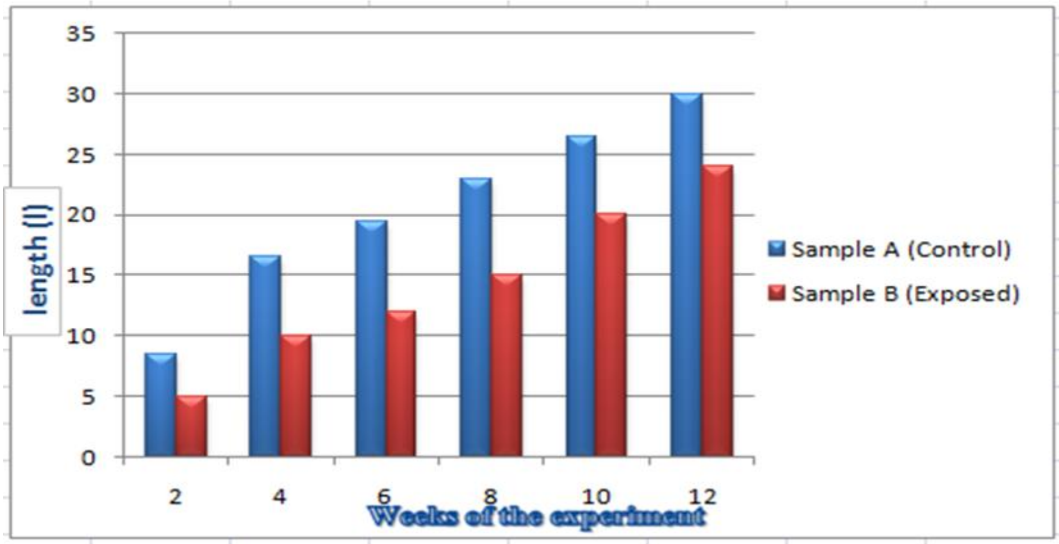

Fig. 2: Bar chart analysis of groundnut length difference experiment (near field)

The biochemical and molecular modifications observed after plant exposure to EMF and described might induce morphogenetic alterations of plant development (Schmidtpott *et al.*, 2022) and this may affect the growth of plant thereby leading to modifications in its development from seed to leaves and even seedlings. This is because the RF-EMF can be felt no matter the size of the biologic sample in consideration. Observations from this study shows that the leaves in the control group were green thus the chlorophyll pigmentation was unaffected but there was a drop in the chlorophyll content of the exposed group. Upadhyaya *et al.* (2022) in a study on Inhibitory effects of low thermal radiofrequency radiation on physiological parameters of Zeamays seedlings growth reported that when 12-day-old maize seedlings were exposed to 1GHz EMF there was a reduction in photosynthetic pigment content.

Czerwiński *et al.* (2023) investigated the influence of radiofrequency and microwave electromagnetic waves of non-thermal power density upon the assimilatory pigments in the vegetal tissues showed that exposure of maize seedlings to microwave also caused a drop in chlorophyll a and b content and that exposure to EMF of high frequencies over a long period of time lead to inhibitory effects on biochemical parameters. These growth reductions may be related to a lower photosynthetic potential and the modifications may be related to abnormal photosynthetic activity, which relies on many parameters, including chlorophyll and carotenoid content (Izadpanah *et al.,* 2023).

IV. Conclusion

In conclusion, the influence of radio-frequency radiation from mobile base stations (e.g. GSM mast) to plants can cause the physiological and metabolic changes that influence their growth, adverse changes in the green part of the plant and delay in seed germination. With effect of radio-frequency radiation from GSM mast and other electromagnetic microwave radiation, it was observed from the experiment that there were negative effects of radio-frequency radiation from GSM mast on the groundnut plant. The result was the slowing of plants growth, adverse change in coloration, physiological and metabolic changes, and genetic mutations that can lead to death of the plants. However, further studies are recommended.

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