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EFFECTS OF 2G, 3G AND 4G MOBILE PHONE RADIATIONS ON GERMINATION OF SEEDS AND BIOCHEMICAL PROCESSES OF *VIGNA RADIATA* AND *PHASEOLUS VULGARIS*

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ABSTRACT

The usage of mobile phones during the last decades has resulted in an increase in the levels of electromagnetic radiations in natural environments causing electromagnetic pollution like electromagnetic field smog which has harmful effects on the living organisms. Experiments were conducted to observe the effects of radiations on the plants. It was designed to observe the effects of electromagnetic radiations emitted from mobile phones on the physiological and biochemical changes in the emerging seedlings of *Phaseolus vulgaris* and *Vigna radiata*. The seeds were subjected to three different mobile networks (2G, 3G and 4G). The seeds which were subjected to 4G cell phone radiations showed much earlier seed germination that is within two days of sowing as compared to the 2G and 3G electro-magnetic radiation in which the seed germination was observed after four days of sowing in case of *Vigna radiata*. The percentage of seed germination in *Vigna radiata* reduced to 40%, 25% and 25% in case of the seeds subjected to 2G, 3G and 4G mobile radiations respectively. The seed germination in case of *Phaseolus vulgaris* was delayed for four days of sowing the seeds. Only 25% of the seeds were germinated in each of the case. The length of the radicle was found to be 1.4cm, 0.7cm 0.4cm when exposed to 2G, 3G and 4G mobile radiations respectively in case of *Vigna radiata* whereas it was found to be 2.1cm, 3cm and 6.5cm when exposed to 2G, 3G and 4G mobile radiations respectively in case of *Phaseolus vulgaris*. The height of the seedlings of *Vigna radiata* is maximum in-case of the seedlings that were subjected to 2G cell phone radiations which was found to be 2.2cm. The radiations greatly interfered in the biochemical processes of the seedlings of both the varieties. There was a marked decrease in the carbohydrate, lipid, protein and chlorophyll contents in case of both the varieties. The total chlorophyll content in *Vigna radiata* was found to be minimum in case of the seedlings exposed to 4G mobile radiations i.e 200µg/ml. The total chlorophyll content in *Phaseolus vulgaris* was found to be minimum in case of the seedlings exposed to all the three types of mobile radiations i.e 340µg/ml. The lipid content was reduced when compared with that of the control seedlings, but it was found to be minimum in case of plants of *Vigna radiata* when exposed to 4G radiations that is 0.06gm and in case of plants of *Phaseolus vulgaris* when exposed to 3G radiations that is 0.4gm. The carbohydrate concentration was reduced in case of plants exposed to mobile radiations as compared to that of the control plants. It was found to be minimum in case of the seedlings of both *Vigna radiata* and *Phaseolus vulgaris* when exposed to 4G radiations which was 0.09mg/ml and 0.6mg/ml respectively.

KEYWORDS: Mobile phone radiations, Seed germination, Biochemical processes, electromagnetic field smog, electromagnetic pollution, *Phaseolus vulgaris*, *Vigna radiate.*

1. INTRODUCTION

1.1 Mobile Radiation

Mobile communication is one of the continuously growing and latest areas which are developing at an alarming rate, with advanced techniques emerging all the fields of mobile and wireless communications. A cellular network or a mobile network is a radio network distributed over land areas called cells, each served by at least one fixed location transceiver, known as cell site or base station in a cellular network, each cell uses a different set of frequencies from neighbouring cells, to avoid interference and provide guaranteed bandwidths within each cell. Cell phone signals were versed on analogue system and transmission. By this method, houses, wireless tele-communications networks and

enterprise (business) installations avoid the costly process of introducing cables into building. Wireless telecommunication developments being driven passively by the transformation of what has been largely a medium for supporting voice telephony into a medium for supporting other services like transmission of videos, images, texts and data. The number of mobile phones users were increased from about 2.2 to 5.9 billion between 2005 and 2011 (key global telecom indicators, 2012). Approximately four mobile phone service providers exist in a given geographical area (Hyland (2005)). Consequently, the number of base stations was also increased to support the tremendous growth of mobile phone users (WHO, 2006). The cell phone antennae generate signals, radiation waves that are similar to those produced by our bodies' own electrical system (Kovach (2007)). The danger of radiation is not from "direct damage, but rather due to the biochemical responses in the cell'' (kovach 2007). The Interphone study (INTERPHONE Study Group, 2010) (some evidence to suggest increased risk of glioma in heavy adult users > 1640hours) (Geoffry et al. 2009) indicate the growing risk of malignant brain tumours for users of cellular and cordless phones. The results from these studies have not been without controversy. The analysis presented in another study by (Geoffry et al. 2009) proposes that there is no increase in risk, with accumulating evidence suggesting the fact that mobile phone use is safe for adults.

1.2 Experimental Plants used in the study

Legumes are the special plants which have ability to fix nitrogen because of their nature of symbiosis with *Rhizobium* bacteria (Sharma and Parihar (2014)). In bacteria, bacteroids were responsible for the formation of nodule in the root (Sharma and Parihar (2014)). Now-a-days many towers are building in the field and many other places near the agricultural fields which affect the plants in all different aspects. The radiations effect may be positive or negative on the growth and development of plants. It is interesting to note that microwave power levels used for this study are comparable to the power levels being used in mobile phones. They are well below the permitted international safety standards for the general public. Since experiments on humans with microwaves are difficult, plants would be a better choice to study the overall effect on growth, productivity, biochemical and physiological parameters. Studies on plants do not need special facilities and have no statutory obligations. Hence, we have selected popular crops, *Phaseolus vulgaris*, *Vigna radiata* for our study. The germination of seeds and the growth rate are important features for maximizing the productivity that need a close observation. Radiations are known to induce physiological and genetic modifications viz. production of various epidermal meristems in the hypocotyl, modifications of the proteome etc.

1.3 Cell phone Technology

2G, 3G AND 4G CELL PHONES: The 'G' stands for generations, and they refer 2^{nd}, 3^{rd}, 4^{th} generations of wireless technology. The newer generation is faster, more secure and reliable. 1G is an analogue technology and the phones generally had poor battery life, voice quality was large without much sensing and would sometimes experience have dropped cell. Then 2G telephone technology was introduced with call and text encryption, plus data services like short message communication, picture messages and mails. 3G was introduced as the faster data transmission speeds so we can use our cell phones in mere data demanding ways like for video calling and mobile network. Then in the same way 3.5 G and 3.75 G was also introduced with more features. Then 4G came in 2008, the 4^{th} generation of network. Gaming series, video conferencing, HD mobile TV were accessed through greater network strength. 2G and 3G cell phone there are different types of cell phone technologies which are used today 1G, 2G, 3G, and 4G. The most widely used cell phone technologies are 2G and 3G. 2G are second generation wireless telephone. 2G phone irradiates in 800-1500MHz frequency and 3G phones irradiates 1500-2400 MHz frequency of radiation.4G comes after that and having frequency range of MHz 3500-8000MHz radiation emitted from cell phone give a harmful effect on both plants and animals. It has been shown that the radiations emitted from mobile phone are carcinogenic for human being. Beside this they also have harmful effect on the plants (Sharma and Parihar (2014).

In this study the main objective was to check the in vitro and in vivo effect of 2G and 3G and 4G mobile phone radiations on two selected seeds and their seedling biochemical contents.

2. MATERIALS AND METHODS

2.1 Materials

1. Glass chamber or box, Seed materials, Mobile phones, Petri plates, Support media.
2. Plant Material: Healthy seeds *Phaseolus vulgaris*, *Vigna radiate.*

2.2 Methods

2.2.1 Seed germination

To conduct the experiments, Petri-plates were taken with filter papers at their bases. The filter papers were soaked with water sprayer frequently to maintain the moisture. Then the selected healthy seeds from each plant were taken and soaked in water overnight to absorb sufficient moisture to facilitate proper germination. Then seeds were removed from the water and placed in a wet cloth to enhance germination of the seeds. A total of 40 seeds were sowed in different Petri plates each containing 5 numbers of seeds. Among them 5 of each plant seeds were designated as control. And others were designated as experimental seeds. The seeds were moisturised intermittently with the water sprayer. Control box remained open to outside all the times, whereas

experimental boxes were provided with lid to make them air tight at the time of radiation exposure by cell phones. One chamber is provided with 2G radiation. Then other one was irradiated with 3G radiation. Then 3rd one is provided 4G radiation. Then the control was kept without any kind of radiations. The radiation was given in each 2hrs of gap on daily basis for 4 days till all the seeds germinate to small plantlets. In total 8hrs of radiation was given in daily basis in each chamber. The radiation was provided in dose dependent and time dependent manner. Then the observations were taken for both control and experimental plant materials after 5 to 6 days. And for chlorophyll analysis the plants were given exposure for 10 days. Then after 15 days the plants were examined for chlorophyll analysis.

2.2.2 Radiation to seeds

The seeds were subjected to the following radiation in a time dependent manner- Morning radiation, Afternoon radiation, and Evening radiation

2.2.3 Germination and Physiognomic study of seed

After the exposure to radiations the seeds are studied for the time of their germination periods. Then effect of different kind of radiations was studied properly. The physiognomic study includes the study of number of germinated seed, height of seedling, length of radical, the colour of seedling, girth of hypocotyls region, colour of cotyledons, colour of seedling etc.

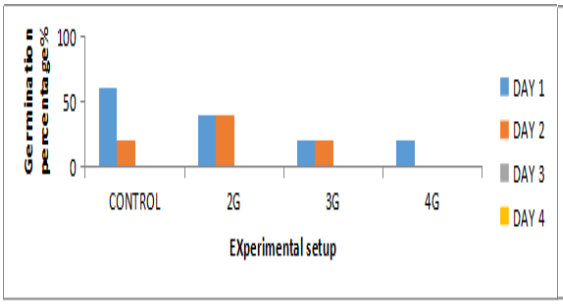
2.2.4 Biochemical analysis of leaf and seedling

Chlorophyll estimation (Figure 7 and 8), Lipid extraction estimation (Figure 9 and 10), Carbohydrate estimation (Figure 11 and 12), Protein estimation (Figure 13) were done regarding the biochemical aspects of the germinated seeds under the experiments.

3. RESULTS

3.1. Effect on seed germination

Two different kinds of seeds such as green gram (*Vigna radiata*) and common beans (*Phaseolus vulgaris*) were chosen. To perform the experiment, four sets of each with five seeds were taken with one set up for control and three sets for experiments. The observations were shown in figures (Figure 1 and 2).



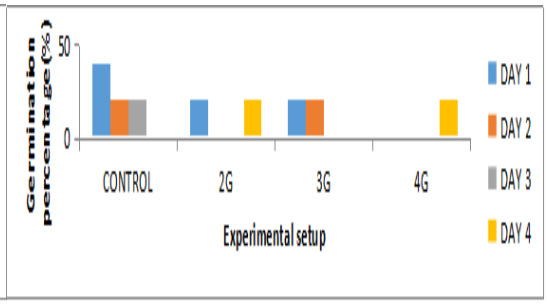
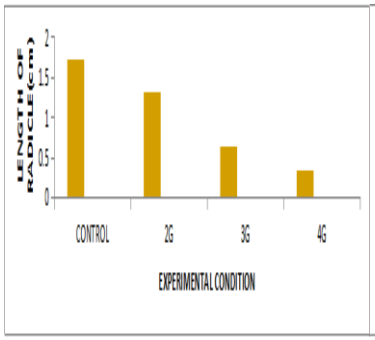
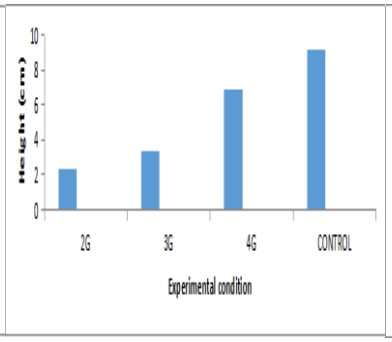


Figure 1: Germination percentage of green gram (*Vigna radiata)* (left).
Figure 2: Germination percentage of common bean (*Phaseolus vulgaris*) (right).

3.2 Morphological study of seedlings

Morphological study of the germinated seeds was as follows: (A) Length of radicle (Figure 3 and 4) (B) Height of seedling (Figure 5) (C) Colour of seedlings (Table 1 and 2).





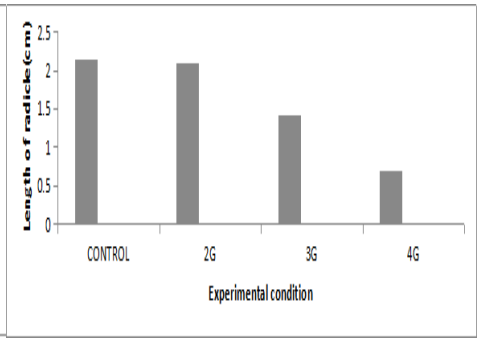


Figure 3: Length of radicle in green gram *(Vigna radiata*) (left).
Figure 4: Length of radicle in common bean *(Phaseolus vulgaris*) (middle).
Figure 5: Height of seedling of green gram (*Vigna radiata*) (right).

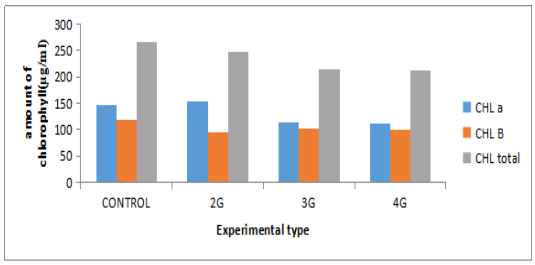
Table 1: Colour of irradiated seedlings in Greengram (*Vigna radiata*).

Serial no.	Experimental seedling	Conditions	Colour of seedlings
1	*Vigna radiata*	CONTROL	out of 5 seedlings all are green in colour
2		2G	Out of the 5 seedlings 4 are greenish and one light green
3		3G	5 seeds out of which 3 are greenish and 2 others are light green.
4		4G	4 seedlings are whitish slightly.

Table 2: Color of irradiated seedlings, Common bean (*Phaseolus vulgaris*).

Serial no	Experimental seedling	Conditions	Colour of seedlings
1	*Phaseolus vulgaris*	CONTROL	All seedlings are green in colour.
2		2G	Colour of 5 seedlings is green.
3		3G	1 seedling out of five is light green to whitish in color.
4		4G	3 seedlings are green in colour and remaining 2 have light green to yellow

3.3 Biochemical estimation



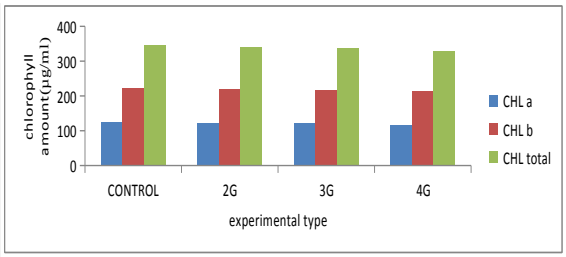
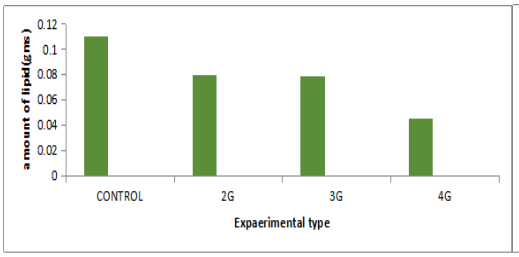


Figure 7: Chlorophyll content of irradiated seeds in green gram *(Vigna radiata)* (left).
Figure 8: Chlorophyll content of irradiated seeds in common bean (*Phaseolus vulgaris)* (right).



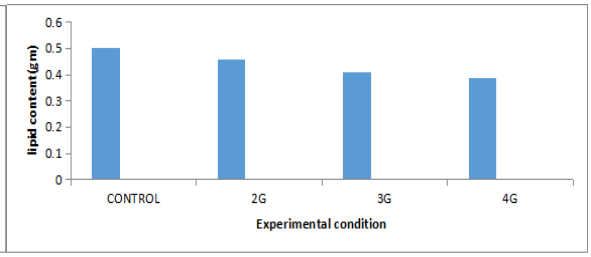
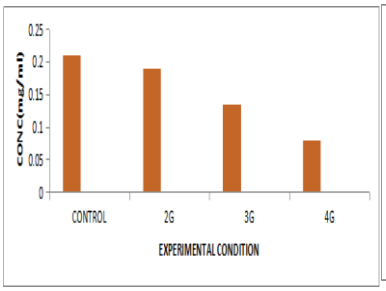
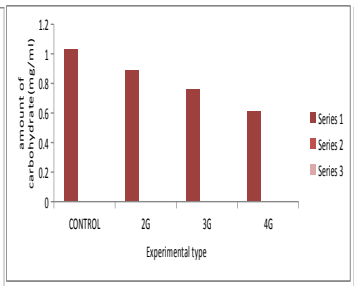


Figure 9: Lipid content of irradiated seeds in green gram *(Vigna radiata)* (left).
Figure 10: Lipid content of irradiated seeds in common beans (*Phaseolus vulgaris*) (right).





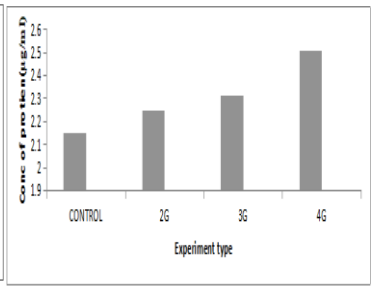


Figure 11: Carbohydrate contents of irradiated seeds, green gram (Vigna radiata) (left).
Figure 12: Carbohydrate content of irradiated seeds, common bean (Phaseolus vulgaris) (middle).
Figure 13: Protein content of irradiated seeds, Green gram (Vigna radiata) (right).

4. DISCUSSION

By studying the seed germination frequency, we conclude that the non-ionizing radiation like RF waves from different cell phones had affected the seed germination. The percentage of seed germinated decreases by increasing the frequencies. When we provided highest energy more frequency radiations from 2G, 3G to 4G the seed germinated was seen declined as compared to control. When radio frequency wave was switched to 3G and 4G radiations having more frequency and energy the seedlings growth got lowered. The height of the seedlings was seen increased effectively. In both the cases the seedlings showed a clear increase. The

effect of radiation on the length of radical was much more different, as the frequency and energy increased the length of seedlings decreases shows detrimental effect. Root growth decreased due to a possible effect of oxidative stress in the state of dormant seeds. The 3G, 4G irradiated plants showed light green coloured stem, as compared to 2G and control seedlings.

The chlorophyll content also decreased with increase in radio wave frequency from 2G to 3G and then to 4G as compared to control. All these seedlings showed a gradual degradative effect. The total carbohydrate contents of hypocotyls part of seedling were taken into experiments which showed the degradative effect as the application of radiation energy and frequency was increased from 2G to 3G and to 4G onwards. The lipid content also decreases with increase in frequency of radiation from lower to higher energy frequency. Both these experimental plants showed derogative effect due to the metabolic and other biochemical changes. The amount of protein present in the sample was increased as the sample was irradiated with higher energy and frequencies. This might be due to the radiation prone protein development and formation of stress related protein and/or metabolic changes. The shock proteins might have developed in response to the higher frequency radiation.

5. CONCLUSION

Overall effect of RF-EMF radiation has degradative effect on plants; radiation frequencies reduce the chlorophyll content, biomass and lipid amounts. The cell phone towers and day to day use of connectivity devices like blue tooth, hotspots also emit more frequency radiation. The networks are upgrading day to day basis like 2G to 3G to 4G that actually causing damage to the living beings including plants. Concerns have also been raised that continuous exposure to EMF radiation emanating from telecom towers causes harmful thermal and non-thermal effects on plants and other biological systems. Immediate steps should be taken in order to avoid or to rectify these problems.

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