Journal of Environment Pollution and Human Health, 2014, Vol. 2, No. 4, 85-90
Available online at http://pubs.sciepub.com/jephh/2/4/3
© Science and Education Publishing
DOI:10.12691/jephh-2-4-3

Effect of Two Brands of Cell Phone on Germination Rate and Seedling of Wheat (*Triticum aestivum*)

Rim A. Hussein*, Magda A. El-Maghraby

Environmental Health Department, High Institute of Public Health, Alexandria University, Egypt
*Corresponding author: rimahamid@yahoo.com

Received October 04, 2014; Revised October 20, 2014; Accepted October 24, 2014

Abstract This study aimed at assessing the effect of radiation emitted from two brands of cell phones; in both (talking) and (non-talking) status, on the germination rate and the embryonic stem length of Wheat seeds *(Triticum aestivum*) following varying durations of exposure (5, 10, 15, 20, 25 up to 30 minutes) and from different distances from the cell phone (5cm, 10cm and 15cm). Statistical analysis was done using Statistical Package for Social Sciences SPSS 16. Regression models were used to estimate the adjusted predictability of germination rate and embryonic stem length. Exposure to cell phone radiation was found to have an inhibitory effect on germination rate and embryonic stem length of Wheat seeds *(Triticum aestivum*). As for germination rate, the inhibitory effect was not statistically significant for duration of exposure up to 30 minutes, a distance from the cell phone as close as 5 cm and with exposure to two different cell phone brands. On the other hand, significant decline in number of germinated seeds compared to control group was observed when cell phone was used in the (non-talking) status than in the (talking) status (p = .006). A logistic regression was performed to ascertain the effects of different variables on the likelihood of germination. According to the model, seeds exposed to cell phone brand B were .8 times less likely to germinate than those exposed to cell phone brand A. In addition, seeds exposed to cell phone in the non-talking status were .714 times less likely to germinate than those exposed to a talking cell phone. Concerning the effect on embryonic stem length, distance from cell phone, cell phone brand, and cell phone status (talking/non-talking) had statistically significant inhibitory effects on embryonic stem length of exposed seeds as determined by one-way ANOVA (p = .001, .000 and .007 respectively). A linear regression was performed to ascertain the effects of different variables. According to the model, distance from cell phone and cell phone brand negatively predicted embryonic stem length (B= -.218 and -.636 respectively). Cell phone brand was stronger predictor than distance from cell phone (p = .000 and .007 respectively). Based on the results obtained, one can conclude that there is a certain effect on germination rate and embryonic stem length from exposure to cell phone radiation. Such effect might be affecting human beings using cell phones. More studies are needed to clarify the basis of these effects in order to be able to prevent negative ones.

Keywords: *cell phone radiations, germination rate, embryonic stem length, wheat (Triticum aestivum)*

Cite This Article: Rim A. Hussein, and Magda A. El-Maghraby, "Effect of Two Brands of Cell Phone on Germination Rate and Seedling of Wheat (*Triticum aestivum*)." *Journal of Environment Pollution and Human Health*, vol. 2, no. 4 (2014): 85-90. doi: 10.12691/jephh-2-4-3.

1. Introduction

Globally, there is an ever-growing number of cell phone users. This has been accompanied by an increase in public concern about the possible hazards of this technology and has necessitated an evaluation of its effects on different users. [1] Several studies have been carried out to investigate the effect of cell phone radiation on living cells. Particular attention has been given to the effect on human health, [2] in addition to some researches that have focused on other biological systems including plants [3].

One study conducted on tomato plant (*lycopersicon esculentum*) concluded that exposure to low-level electromagnetic fields (EMF) for 10 minutes had a stimulus effect on the plant similar to wound response, this proved that radiation was perceived by the exposed plant as injurious stimulus. [4] In duckweed (*Lemna minor*), exposure to radio-frequency fields induced oxidative stress as well as a non-specific stress response. [5] In mung bean (*Vigna radiata*), EMF radiation had an inhibitory effect on root growth, and the inhibitory effect was found to be time-dependant. [6] Similarly, a decrease in root growth was observed in lentils (*Lens culinaris*) seeds exposed to cell phone radiation. while germination rate was not affected. [7] On the other hand, when onion (*Allium cepa*) seeds were exposed to different strengths of EMF for two hours, both root length and germination rate were not affected, but mitotic index was increased significantly, and mitotic aberration was induced. [8] In a further study, cell mitosis was examined microscopically after exposing the cells to EMF similar to that produced by cell phones, and no change was found in neither

sequence of mitotic events, nor total duration of mitosis, nor duration of each phase. [9] Finally, a study conducted on Pisum sativum (Pea) and Trigonella foenugraecum (Fenugreek), revealed that radiation emitted from cell phone lead to considerable increase in the germination percentage, seedling length, proteins, lipid and guaiacol content in comparison to control seeds. The biochemical parameters measured were found to increase with increase in the radiation exposure duration. The study concluded that radiations emitted from cell phone interfere with both morphological and biochemical processes and affect growth in plants [10].

Wheat (*Triticum aestivum*) is a cereal of the Gramineae family. Externally, development of the wheat grain is characterized by changes in colour and increases in dry and fresh mass and length. The grain grows rapidly in length, attaining its maximum length in about ten days. As growth proceeds, the endosperm becomes firmer until, at physiological maturity, the green color is replaced by golden-yellow, which deepens as the grain desiccates to ripeness [11].

This study aimed at assessing the effect of radiation emitted from two brands of cell phones; in both (talking) and (non-talking) status, on the germination rate and the seedling of Wheat seeds *(Triticum aestivum*) following varying durations of exposure and from different distances from the cell phone, in order to identify which brand and which status has less effect than the other, and to determine a distance as well as a duration of exposure to cell phones with no significant effect on the exposed seeds.

2. Material and Method

Two cell phone brands (A and B) were selected for the study; they are the most widely used brands in Egypt. Wheat seeds, bought from Egyptian market, were soaked overnight, and the swollen seeds were selected for the study (rupture of seed coat was taken as indicator of an alive embryo). For each cell phone brand, 1080 seeds – distributed as shown in Table 1 - were used. In addition, 30 seeds that have not been exposed to any cell phone were used as control. This made a total of 2190 seeds that were included in the study.

Three variables were studied for each brand: duration starting from 5, 10, 15, 20, 25 up to 30 minutes, distances from the cell phone: 5cm, 10cm and 15cm, and cell phone status: (talking) and (non-talking).

Seeds were brought to germinate on medical cotton soaked with tap water for ten days during which tap water was used for irrigation. Number of germinated seeds in each group, and embryonic stem length were recorded on the tenth day of the experiment.

3. Statistical Analysis

Statistical analysis was done using Statistical package for Social Sciences SPSS 16 [12].

Germination rate was determined as frequency and percentage; while embryonic stem length was determined as mean and standard deviation. Differences in germination rate and stem length between groups were tested using chi-square and ANOVA statistics respectively. Correlation between germination rate and different variables was done using Spearman correlation. The level of significance was set at *p* values less than .05.

Regression models were used to estimate the adjusted predictability of germination rate and stem length. Variables in the models were duration of exposure (from 5 to 30 minutes, on 5 minutes intervals), distance from cell phone (5, 10 or 15 cm), cell phone brand (either A or B) and status (either talking or non-talking).

Table 1. Distribution of study sample (Wheat seeds) used according to cell phone status, distance from cell phone and duration of exposure

Status	Distance, cm	Duration, min	Seed number (n)
Talking	5	5	30
		10	30
		15	30
		20	30
		25	30
		30	30
	10	5	30
		10	30
		15	30
		20	30
		25	30
		30	30
	15	5	30
		10	30
		15	30
		20	30
		25	30
		30	30
Non-talking	5	5	30
		10	30
		15	30
		20	30
		25	30
		30	30
	10	5	30
		10	30
		15	30
		20	30
		25	30
		30	30
	15	5	30
		10	30
		15	30
		20	30
		25	30
		30	30
Total			1080

4. Results and Discussion

a. Effect of cell phone on germination rate:

First, concerning germination rate, 26.7% of seeds germinated in the control group in contrast to lower percentages in exposed groups (Figure 1). However, as presented in Table 2, Chi- square test revealed that varying duration of exposure to cell phone, varying distances from cell phone, and exposure to two different cell phone brands did not lead to any statistically significant difference in number of germinated seeds. On the other hand, number of germinated seeds was significantly less in case of cell phone in the (non-talking) status than in the (talking) status (p = .006). A Spearmen correlation was run to determine the relationship between seed germination and different variables. There was a small, statistically significant positive correlation between

germination rate and cell phone brand (r = .05, p < .05), as well as cell phone status (r = .07, p < .01).

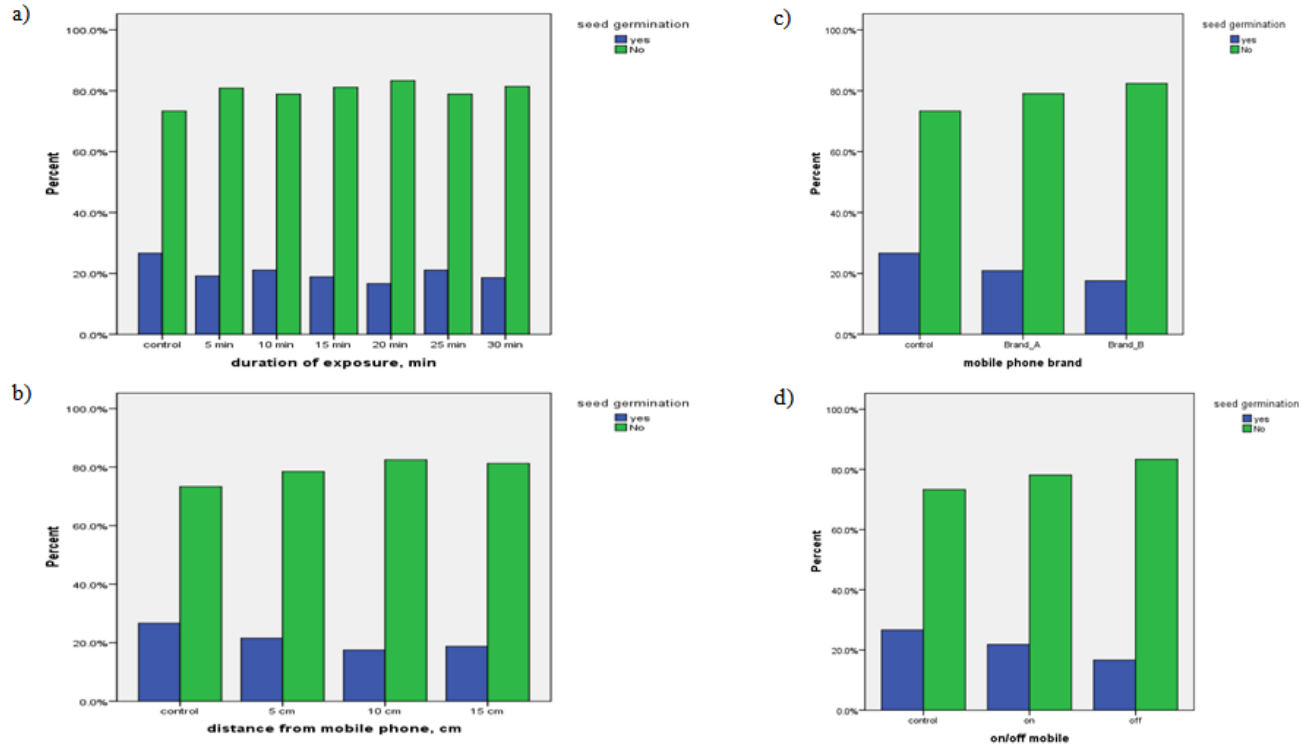

Figure 1. Germination rate among Wheat seeds exposed to cell phone according to a) duration of exposure, b) distance from cell phone, c) cell phone brand, and d) cell phone status either talking (on) or non-talking (off)

Table 2. Effect of distance from cell phone, duration of exposure, cell phone brand and cell phone status on germination rate of Wheat seeds exposed to cell phone

	Germinated Seeds		*p*
	n/total number of seeds	percentage	
Control	8/30	26.7	
Distance, cm			
5	155/720	21.5	.175
10	126/720	17.5	
15	135/720	18.8	
Duration, min			
5	69/360	19.2	
10	76/360	21.1	
15	68/360	18.9	.636
20	60/360	16.7	
25	76/360	21.1	
30	67/360	18.6	
Cell brand			
A	226/1080	20.9	.087
B	190/1080	17.6	
Cell status			
Talking	236/1080	21.9	.006*
Non-talking	180/1080	16.7	

Test used was Chi Square.
* *p* significant at <.05.

A logistic regression was performed to ascertain the effects of exposure distance and duration, as well as cell phone brand (A or B) and status (talking/non-talking) on the likelihood of germination rate. The logistic regression model was statistically significant, *p* <.0005. According to the model, seeds exposed to cell phone brand B were .8 times less likely to germinate than those exposed to cell phone brand A. In addition, seeds exposed to cell phone in the non-talking status were .714 times less likely to germinate than those exposed to a talking cell phone.

As a conclusion, the present study showed that exposing wheat seeds to cell phone radiation for varying duration and from varying distances lead to a decline in the number of germinated seeds in exposed group compared to control group, even though such decline was not statistically significant either from brand A or brand B cell phones. This was in accordance with a number of studies conducted on other seeds: Mustard (Brassica campestris) seed germination was reduced after being exposed to cell phone, [13] wheat (*Triticum aestivum*), bengal gram (*Cicer arietinum*), green gram (*Vigna radiate*), and moth bean (*Vigna aconiti-folia*) seed germination was reduced after being irradiated with microwave radiation. In agreement to our findings, reduction in germination of these seeds was found to occur corresponding to increase in exposure time or decrease in power density caused by any increase in the distance from radiating source [14,15].

Results were also in accordance with studies carried out on other biological systems including *Entamoeba histolytica* and *Entamoeba dispar* where significant decrease in the number of living parasites compared to the control group was observed after exposure to cell phone radiation. [16] Similarly, chicken eggs were exposed to EMF from cell phone during the embryonic development (for 21 days). As a result embryo mortality rate in the incubation period increased to 75% versus 16% in control group, [17] and in another study, embryonic mortality in exposed eggs was significantly higher than in the control group (14.3% versus 1.6% respectively, *p* <.001). [18] Finally, many studies have confirmed that sperm counts and viability were lower in individuals using cell phones

intensively compared to men who did not have or use them [19, 20].

On the other hand, results of the actual study were not in agreement with researches performed on *Lens culinaris* and *Allium cepa* where exposure to cell phone radiation was found not to have any effect on seed germination rate. [7,8] In addition, and contrarily to our findings, a study was carried out on *Vicia faba* grains that were irradiated by cell phone waves three times a day, 10 minutes each time for 14 days, and results indicated that the percentage of germination in test group increased compared to control group. [21] A second one was conducted on Pisum sativum and Trigonella foenugraecum, and revealed that radiation emitted from cell phone lead to considerable increase in the germination percentage. [10] Such variation in the results could be due to difference in type of seeds under study, type of cell phone used, as well as different conditions of the experiments including duration and frequency of radiation.

Furthermore, the present study highlighted the effect of cell phone in the non-talking status being more harmful on seed germination than on the talking status (seeds exposed to cell phone in the non-talking status were .714 times less likely to germinate than those exposed to a talking cell phone). This could be explained by the fact that when a phone is on and not in use, it sends out some intermittent signal to connect with nearby cell phone towers. These signals radiation could be higher than the level of radiation emitted during actual conversation. Because of this, it is not recommended to keep a cell phone on the body, in a pocket or on the belt where nearby tissues would absorb radiation. A handbag, briefcase or a nearby surface is probably a better place for a cell phone in the "on" position. Besides, the cell phone industry should test each phone's radiation in real-life scenarios, with different providers and radiation frequencies, at varying distances from cell phone towers and during different forms of use such as texting, making phone calls or surfing the internet. Information obtained from such researches should be disseminated to the public [22].

b. Effect of cell phone on embryonic stem length:

Second, concerning embryonic stem length, it was generally shorter in exposed groups than in control group (Figure 2). One-way ANOVA was run to determine the effect of each variable (Table 3).

Table 3. Effect of distance from cell phone, duration of exposure, cell phone brand and cell phone status on embryonic stem length of Wheat seeds exposed to cell phone

	Embryonic stem length, cm (mean ±SD)	95% Confidence Interval for Mean		Sig.
		Lower Bound	Upper Bound	
Control	2.9 ± 5.8	.74	5.1	
Distance, cm				
5	1.4 ± 3.6	1.2	1.7	.001**
10	1.0 ± 2.9	.81	1.2	
15	1.0 ± 2.8	.82	1.2	
Duration, min				
5	1.2 ± 3.4	.87	1.6	
10	1.3 ± 3.1	.96	1.6	
15	1.2 ± 3.2	.82	1.5	.140
20	1.1 ± 3.2	.81	1.5	
25	1.1 ± 2.9	.76	1.4	
30	1.2 ± 3.1	.85	1.5	
Brand				
A	1.5 ± 3.5	1.3	1.7	.000**
B	0.9 ± 2.7	0.7	1.0	
Status				
Talking	1.2 ± 2.9	1.1	1.4	.007*
Non-talking	1.1 ± 3.3	0.9	1.3	

Test used was ANOVA
* *p* significant at <.05
***p* significant at <.005.

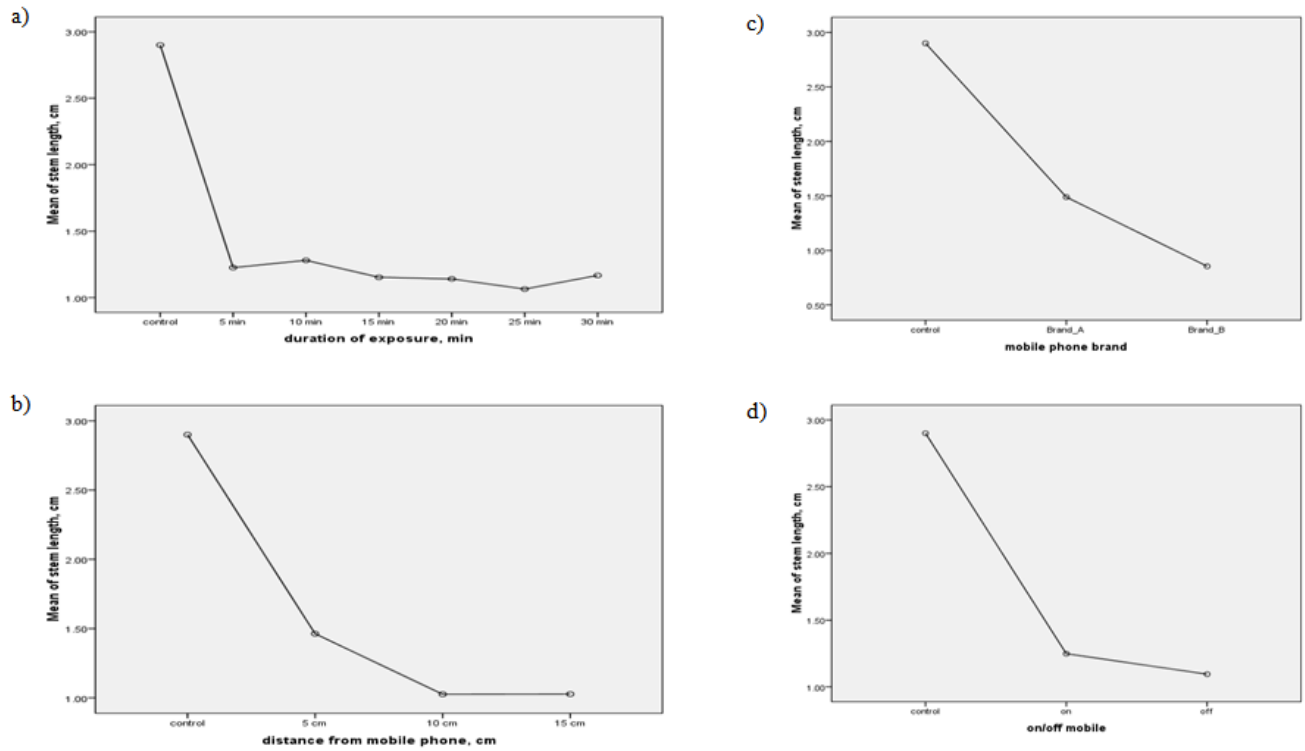

Figure 2. Embryonic stem length among Wheat seeds exposed to cell phone according to a) duration of exposure, b) distance from cell phone, c) cell phone brand, and d) cell phone status either talking (on) or non-talking (off)

As regards to distance from cell phone, it was found that exposure to cell phone from varying distance lead to a statistically significant difference in embryonic stem length between groups (p = .001). A Tukey post-hoc test revealed that embryonic stem length was statistically significantly shorter after exposing the seeds to cell phone starting from a distance of 10 cm (1.0 ± 2.9 cm, p = .009) and 15 cm (1.0 ± 2.8 cm, p = .009) compared to control group (2.9 ± 5.8 cm). There was no statistically significant differences between stem length of seeds exposed to cell phones from 5 cm distance (1.4 ± 3.6, p = .073) and control group. There was also a statistically significant difference between embryonic stem length of seeds exposed from 5 cm to cell phone and those exposed from 10 cm (p = .045) and 15 cm (p = .046). No statistically significant difference was observed between embryonic stem length of seeds exposed to cell phones from 10 and 15 cm distance (p = 1.000).

Concerning duration of exposure to cell phone and its effect on embryonic stem length, there was no statistically significant difference between groups as determined by one-way ANOVA (p = .140).

As for cell phone brand, it had a statistically significant effect on embryonic stem length of exposed seeds as determined by one-way ANOVA (p = .000). A Tukey post-hoc test revealed that embryonic stem length was statistically significantly shorter after exposing the seeds to cell phone brand A (1.5 ± 3.5 cm, p = .043) and brand B (0.9 ± 2.7 cm, p = .001) compared to control group (2.9 ± 5.8 cm). There was also a statistically significant difference between embryonic stem length of seeds exposed to cell phone brand A and those exposed to brand B (p = .000).

With respect to cell phone status, there was also a statistically significant difference between groups as determined by one-way ANOVA (p = .007). A Tukey post-hoc test revealed that embryonic stem length was statistically significantly shorter after exposing the seeds to cell phone in the talking status (1.2 ± 2.9 cm, p = .014) as well as the non-talking status (1.1 ± 3.3 cm, p = .006) compared to control group (2.9 ± 5.8 cm). On the other hand, there was no statistically significant difference between embryonic stem length of seeds exposed to cell phone in both talking and non-talking status (p = .502).

A linear regression was performed to ascertain the effects of exposure distance and duration, as well as cell phone brand (A or B) and status (talking/non-talking) on embryonic stem length. The linear regression model could predict embryonic stem length significantly well, p <.0005. According to the model, distance from cell phone and cell phone brand negatively predicted embryonic stem length (B= -.218 and -.636 respectively). Cell phone brand was stronger predictor of embryonic stem length than distance from cell phone (p = .000 and .007 respectively).

Therefore, the present study showed that stem length was generally shorter in exposed groups compared to control group. This was in agreement with a previous study conducted on similar seeds (wheat seeds) irradiated in microwave, that found that the length of the plant decreased as the time of microwaving increased. [14] Another study carried out on thistles (*Cynara cardunculus*) and lentils (*Lens culinaris*) exposed to EMF, revealed that a decrease in stem length occurred in thistles while an increase in stem length occurred in lentils with respect to control group. The researchers owed such variation to difference in plant response to EMF. They also observed that increase in stem length in lentils was accompanied by fewer branches, lower stem weight, less developed root and fader green color. The same study reported that difference in stem length between exposed and control group started to be significant after the 21st day (p <.001). [23] This could explain why the difference in stem length appearing in the present study was not significant since the maximum exposure duration was 30 minutes rather than days.

Results of the present study were also in accordance with those reported by another one which was conducted on wheat (*Triticum aestivum*), bengal gram (*Cicer arietinum*), green gram (*Vigna radiate*), and moth bean (*Vigna aconiti-folia*) seeds, it revealed that plant height decreased with increase in time of exposure to radiation emitted from a microwave, as compared to control. There was also a reduction in plant height as compared to control with corresponding reduction in power density. Variation in power density was accomplished by increasing the gap between the seeds and the radiating source from 1.5 cm to 5.5 cm in steps of 1 cm while other microwave parameters like power, frequency and exposure time were kept constant. This was also in accordance with our results that showed shorter stem length with longer distance of exposure from the cell phone. This was astonishing as keeping the cell further from seeds was expected to cause longer stem length, but this could indicate better seedling growth at higher power densities [15].

Moreover, a statistically negative significant correlation between increase in pines tree growth and intensity of EMF was found and was confirmed by the fact that the beginning of this decline in growth coincided in time with the start of radar emission station nearby [3].

Our results were also in agreement with those of a research investigating the effect of cell phone radiation on root growth of Onion (*Allium cepa* L.). Researchers concluded that a significant reduction in root growth occurred after exposure for ½, 1, 2, and 4 hours, and that the observed effects markedly depended on the exposure time [24].

As for other biological systems, the negative effect of the magnetic field was also manifested by a research conducted on chicken embryos, which reported lower weight for the hatched chickens when compared with the control group [18].

5. Conclusion and Recommendation

Studies have indicated that low-level radio-frequency fields emitted from wireless devices such as cell phones and cordless phones can penetrate the cell membrane and cause some changes in the cytoplasmic structure and function, which might lead to physiological changes in the living cells [25].

Exposure to cell phone radiation was found to have an inhibitory effect on germination rate and embryonic stem length of Wheat seeds *(Triticum aestivum*). As for germination rate, the inhibitory effect was not statistically significant for duration of exposure up to 30 minutes, a distance from the cell phone as close as 5 cm and with exposure to two different cell phone brands. On the other

hand, significant decline in number of germinated seeds compared to control group was observed when cell phone was used in the (non-talking) status than in the (talking) status (p = .006). A logistic regression was performed to ascertain the effects of different variables on the likelihood of germination rate. According to the model, seeds exposed to cell phone brand B were .8 times less likely to germinate than those exposed to cell phone brand A. In addition, seeds exposed to cell phone in the non-talking status were .714 times less likely to germinate than those exposed to a talking cell phone.

Concerning the effect on embryonic stem length, distance from cell phone, cell phone brand, and cell phone status (talking/non-talking) had statistically significant inhibitory effects on embryonic stem length of exposed seeds as determined by one-way ANOVA (p = .001, .000 and .007 respectively). A linear regression was performed to ascertain the effects of different variables. According to the model, distance from cell phone and cell phone brand negatively predicted embryonic stem length (B= -.218 and -.636 respectively). Cell phone brand was stronger predictor of stem length than distance from cell phone (p = .000 and .007 respectively).

Based on the results obtained, one can conclude that there is a certain effect on germination rate and embryonic stem length from exposure to cell phone radiation. Such effect might be affecting human beings using cell phones. More studies are needed to clarify the basis of these effects in order to be able to prevent negative ones.

References

[1] Ganghi G, Singh P. Cytogenetic damage in mobile phone users: preliminary data. Int J Hum Genet 2005, 5 (4): 259-65.

[2] Moussa M. Review on health effectd related to cell phone. Part II: results and conclusions. Journal of the Egyptian Public Health Association 2011, 86 (5-6): 79-89.

[3] Balmori A. Electromagnetic pollution from phone masts. Effect on wildlife. Pathophysiology 2009, 16: 191-9.

[4] Roux D, Vian A, Girard S, Bonnet P, Paladian F, Davies E, Ledoigt G. High frequency (900 MHz) low amplitude (5Vm−1) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato. Planta 2007; 227: 883-91.

[5] Tkalec M, Malarik K, Pevalek-Kozlina B. Exposure to radiofrequency radiation induces oxidative stress in duckweed *Lemna minor* L., Sci. Total Environ. 2007; 388: 78-89.

[6] Sharma V, Singh H, Kohli R, Batish D. Cell phone radiation inhibits *Vigna radiata* (mung bean) root growth by inducing oxidative stress. Sci Total Environ 2009; 407(21): 5543-7.

[7] Akbal A, Kiran Y, Sahin A, Turgut-Balik D, Balik H. Effect of electromagnetic waves emitted by cell phones on germination, root growth and root tip cell mitotic division of *Lens culinaris* Medik. Pol. J. Environ. Stud 2012; 21 (1): 23-9.

[8] Tkalec M, Malaric K, Pavlica M, Kozlina B, Cifrek Z. Effects of radiofrequency electromagnetic fields on seed germination and root meristematic cells of *Allium cepa* L. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 2009; 672 (2): 76-81.

[9] Moisescu M, Leveque P, Bertrand J, Kovacs E, Mir L. Microscopic observation of living cells during their exposure to modulated electromagnetic fields. Bioelectrochemistry 2008, 74 (1): 9-15.

[10] Sharma S, Parihar L. Effect of Cell Phone Radiation on Nodule Formation in the Leguminous Plants. Curr World Environ 2014; 9(1).

[11] Kirby E. Botany of the wheat plant. In: Curtis B, Rajaram S, Macpherson H, eds. Bread wheat, improvement and production. FAO, Rome, 2002.

[12] Fiddler L, Hecht L, Nelson EE, Nelson EN, Ross J. SPSS for Windows 16.0: A basic tutorial. Social Science Research and Instruction Center. California State University. [Internet] available @ http://www.ssric.org/trd/spss16**.** Last accessed on Aug 25th, 2014.

[13] Singh H, Sharma V. Electromagnetic radiations from cell phone inhibit plant root growth through induction of oxidative damage. Epidemiology 2011; 22(1): 249.

[14] Guyadin L. Do microwaves affect plant growth? Environ Mentor Program 2009 [Internet]. available @ http://pdfmonster.biz/search/Growth+Fetish//58#Do_Microwaves_Affect_Plant_Growth_John_Ohab**.** Accessed on Sep 19th, 2014.

[15] Ragha L, Mishra S, Ramachandran V, Bhatia M. Effects of Low-Power Microwave Fields on Seed Germination and Growth Rate. Journal of Electromagnetic Analysis and Applications 2011, 3, 165-71

[16] Aksoy U, Sahin S, Ozkoc S, Ergor G. The effect of electromagnetic waves on the growth of *Entamoeba histolytica* and *Entamoeba dispar*. Saudi Med J 2005, 26 (9): 1388-90.

[17] Grigorevlu G. Biological effects of cell phone electromagnetic field on chick embryo (risk assessment using the mortality rate)]. Radiats Biol Radioecol 2003, 43 (5): 541-3.

[18] Veterany L, Veteranyova A, Jedlicka J. Effect of magnetic fields on embryonic mortality. Cesk Fysiol 2001, 50 (3): 141-3.

[19] Agarwal A, Deepinder F, Sharma RK, Ranga G, Li J. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. 2007. [Internet]. available @ http://www.clevelandclinic.org/reproductiveresearchcenter/docs/agradoc239.pdf.

[20] Fejes I, Zavaczki Z, Szollosi J, Koloszar S, Daru J, Kovacs L, (Sept-Oct). Is there a relationship between cell phone use and semen quality? Arch Androl 2005 51(5): 385-393.

[21] Arbabian S, Ramezani F, Majd A. Investigation of the effect of cell phone waves on seed germination and seedling ontogeny in *Vicia faba*. Journal of Plant Science Researches 2010, 5 (2): 56-62.

[22] Environmental working group. Guide to safer cell phone use. August 2013 [internet], available @ http://www.ewg.org/cellphoneradiation/faq. Last accessed on Sep 16th, 2014.

[23] Picazo M, Martinez E, Carbonell M, Raya A, Amaya J, Bardasano J. Inhibition in the growth of thistles (*Cynara cardunculus*) and lentils (*Lens culinaris*) due to chronic exposure to 50 Hz, 15 μT electromagnetic fields. Electro-and-magnetobiology 1999, 18 (2): 147-56.

[24] Krishnan R, Murugan K. Effect of Cell Phone Radiation on Antioxidant Machinery in Roots of Onion (*Allium cepa* L.) Asian J. Exp. Biol Sci 2011, 2(4): 667-72.

[25] Repacholi M. Low-level exposure to radiofrequency electromagnetic fields: health effects and research needs. Bioelectromagnetics 1998; 19: 1-19.