

Consequences of Microwave Electromagnetic Radiation Exposure on Germination and Free Proline Content of Green gram and Red bean

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ABSTRACT

Background: Plants are a crucial key component of the well-formed ecosystem and have a significant role in the living world, therefore, it would be helpful to scrutinize their interaction with variable radio and microwave frequency fields.

Objectives: A laboratory test was conducted in October 2018 in the Department of Botany, Jinnah University for Women, Karachi to investigate the microwave radiation influence on plant development, and clarify the mechanisms of energy exchange and stimulation of plant development. The experiment was laid down at a completely randomized design to evaluate the effect of microwave electromagnetic radiation at different durations of time on seed germination and free proline content (stress indicators) in green gram (*Vigna radiata*. L) and red bean (*Phaseolus vulgaris*. L) seedlings.

Methodology: Seeds were treated with three different time periods of microwave radiation (5, 15 & 30sec). Control seeds were not treated.

Results: The analysis of obtained data showed that the differential exposure of microwave had a significant effect on germination rate, germination percentage and free proline content of both plants. The exposed electromagnetic radiation improved the germination rate in both types of seed along with improved germination percentages. Proline contents of both plants also markedly responded with electromagnetic radiation and proved themselves a responsive stress indicator with differential radiation exposures.

Conclusion: The 15sec exposure to microwave radiation enhanced germination in green gram seeds, while 30sec exposure improved red bean seed germination along with breaking the dormancy effect of the hard seed coat. Therefore, the technique provides a quick and effective method of treatment especially for the seeds having an impermeable seed coat.

Keywords

Vigna radiata, *Phaseolus vulgaris*, Electromagnetic radiation, Dormancy, Seed coat, Proline content.

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INTRODUCTION

Microwaves are a type of electromagnetic radiation, as are radio waves, ultraviolet radiation, X-rays and gamma-rays. Microwaves have a range of applications, including communications, radar and, perhaps best known by most

people, cooking. Microwaves radiations range in frequency from 300 million cycles / second (300 MHz) to 300 billion cycles / second (300 GHz)¹, Microwaves are a part of the nonionizing electromagnetic (EM) radiation

spectrum. It deals with polar molecules and charged particles, and cause their agitation called heat. An organic object placed under these waves absorb energy, but the absorbed amount is dependent on the dielectric characteristics of exposed substances². The exposure of microwave radiation of differential frequencies could cause average to severe health damages, depending on their frequency, power level, duration of exposure and the properties of exposed biological tissue (i.e. plant, animal & human) etc. Even though low-level exposures are not instantly noticeable, several previous and current researches have stated that these microwave radiations may cause long-term health effects³. To analyze these consequences on living organisms, plants may become a good selection to check the general effect of microwaves radiations on growth, yield, physiological & Biochemical parameters. Experimentation on plants is more convenient than on animals or humans.

Seed germination and growth rate are the key points for enhancing crop productivity. Some experimental verification showed that magnetic waves (300MHz to 300GHz) may generate several changes in the permeability of cell membrane and overall cell's growth rate, and also interfere with their ions and organic molecules, especially in proteins⁴.

These variations may cause a dramatic change in seed germination, seedling growth and bio-functioning of a plant. Some research findings indicate that there are no significant microwave radiation effects on plants, while others have confirmed significant modifications in plant functioning and growth. However, it is still doubtful that whether pre-treatment of seeds with microwave may cause a change in the seed's inner energy, stimulates enzyme activities, may lead to improved metabolism, and enhances biophoton emission intensity, which is concerned with cell metabolism index^{5,6}. In numerous cases, exposure for a short period resulted in increased germination and vigour of the rising seedlings^{7,8}, but long-term exposure usually caused seed death^{9, 10, 11, 12}. The lethal effect of microwave heating on seeds was first studied by Davis *et al.*^{13, 14}, who reported that microwave oven treated seeds had damage mainly in moisture content as well as energy absorption per seed. In several published investigations concerning agriculture, short term microwave radiation is helpful in triggering seed

germination^{15, 16, 10}. Thus, in this study, we evaluate the effect of microwave radiation (5 Sec, 15 Sec and 30 Sec exposures) on the germinating parameters and physiological functioning of green gram (*Vigna radiata* . L) and red bean (*Phaseolus vulgaris*. L) seeds.

MATERIALS AND METHODS

Experimental Design:

Three sets of green gram and red bean seeds were irradiated by Microwave radiation for the time of 5 sec, 15 sec and 30 sec. Ten healthy, irradiated, sterilized seed of green gram (*Vigna radiata* . L) and red bean (*phaseolus vulgaris*. L) were kept in Petri plates with 1 disc of filter paper under normal laboratory conditions, with temperature ranging from 25-30°C. The same set up was replicated thrice for statistical analysis and control was made with no exposure¹⁷. Germinated seeds were counted and evaluated daily. During the experiment moisture of Petri plates was maintained at constant saturation. Germination rate and germination percentage were recorded at the end of the experiment. All the treated and non-treated seeds were subjected for estimation of free proline according to the method of Bates *et al.*¹⁸ Data was analyzed statistically by software SPSS (version 17). The differences were considered significant at $p < 0.05$ when treated were compared with control.

GERMINATION PARAMETER

1. Germination Rate Index (GRI) was calculated by the following formula, described in the Association of Official Seed Analysts (AOSA, 1983) datasheet.

$$\text{Germination rate index (GRI)} = \{G1 / 1 + G2 / 2 + \dots + G1 / 1\}$$

Where,

G1 = germination percentage on day 1,

G2 = germination parentage on day 2; and so on,

G1 = germination percentage on the final day

2. Seed germination percentage (%) of each treatment was calculated on the 7th day of plating by the formula:

$$\text{Seed germination percentage (\%)} = \frac{\text{Total no. of seeds germinated at end of trial}}{\text{Total no. of seed placed}} \times 100.$$

BIOCHEMICAL ANALYSIS

Free Proline Content of control and treated seedlings were determined in µgm/gm fresh weight according to Bates, L.S., Waldern, And Tears,¹⁸

Inhibitory Percentage (I): The percent inhibition of measured readings was calculated by Surendra and Pota¹⁹, formula: $I\% = \frac{C-T}{C} \times 100$ Where,

I am the inhibition percentage,

T is treatment reading and

C is control reading.

Statistical Analysis: Each tabulated data was subjected to statistical analysis by the software program of SPSS version 17 and displayed as mean ± standard deviation for three replications.

RESULTS

Influence of Microwave Radiation on Germination Parameters

The given data showed that the impact of microwave electromagnetic radiations on germination rate was statically more significant than germination percentages with both studied plants (Table 1a & 1b). The highest germination percentage was achieved with 15 Sec exposure in green gram and with 30 Sec exposure in a red bean. The work of Vashisth and Nagarajan,²⁰ also indicated that the seed germination and early growth of *Cicer arietinum* L. plants were notably improved when exposed to moderate magnetic field²¹.

In the given data, the Germination Rate Index (GRI) of green gram seeds showed significant minimum time required for seed germination when compared to control (Fig. 1a), red bean also exhibited an improved value of GRI with increasing exposure time. According to observed data, exposure of both seeds with microwave radiation support their germination measurements (Fig. 1b). Although the radiation strength is very crucial for this purpose.

Influence of Microwave Radiation on Free Proline Content

Table 2a indicated the proline content that acts as a stress indicator compound within plant tissue. Microwave radiation enhanced the production of proline content of

both plants at the rate of 49% and 86.7% in green gram with 5 sec and 15sec exposures, respectively (Fig. 2a).

While in red bean, proline content was increased from 15% to 233.3% at 5 sec and 15 sec treatment (Fig. 2b). 30sec exposure also had stimulating effects on proline content (+107.49%) of red bean seedling (Table 2b). This increase with slight microwave exposure could save plants from changes that occur under microwave irradiance²¹.

Data Recorded: Germination Measurements

Table 1a. Microwave Radiation effect on Seed Germination Rate Index (GRI)

S. No.	Treatments	Green gram	Red bean
01	0–Sec Exposure (control)	0.8 (0)	0.85 (0)
02	5–Sec Exposure	2.72 (+240)	0.35 (-58.82)
03	15–Sec Exposure	3.27 (+308.75)	0.45 (-47.05)
04	30–Sec Exposure	3.13 (+291.25)	0.57 (-32.94)

Each value is the mean of 3 replicates.

Values in parenthesis indicate % increase (+) or decrease (-) over control.

Table 1b. Microwave Radiation effect on Seed Germination Percentage.

S. No.	Treatments	Green gram (%)	Red bean (%)
01	0–Sec Exposure (control)	90 (0)	70 (0)
02	5–Sec Exposure	100 (+11.11)	70 (0)
03	15–Sec Exposure	100 (+11.11)	80 (+14.28)
04	30–Sec Exposure	100 (+11.11)	90 (+28.57)

Each value is the mean of 3 replicates.

Values in parenthesis indicate % increase (+) or decrease (-) over control.

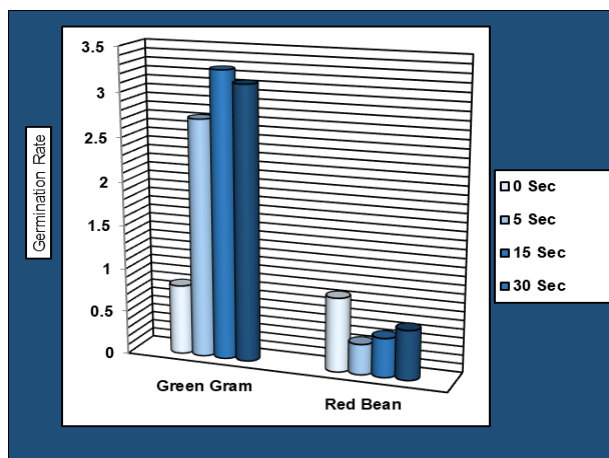


Fig 1a. Microwave radiation effect on germination rate index.

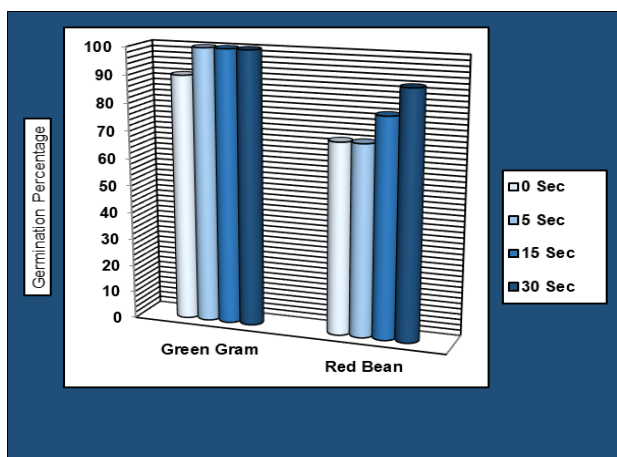


Fig 1b. Microwave radiation effect on germination percentage.

BIOCHEMICAL ANALYSIS:

FREE PROLINE CONTENT (µg/mg)

Table 2a. Microwave Radiation effect on Proline Content of green gram.

S. No.	Treatment	µg/gm (ppm)
01	T0 0–Sec Exposure	0.783 ^c (0)
02	T1 5–Sec Exposure	1.168 ^b (+49.16)
03	T2 15–Sec Exposure	1.462 ^a (+86.71)
04	T3 30–Sec Exposure	0.669 ^d (-14.55)

Each value is the mean of 3 replicates. Values in parenthesis indicate % increase (+) or decrease (-) over control. Means followed by different letters show a significant result at the level of Standard deviation.

Table 2b. Microwave Radiation effect on Proline Content of Red Bean.

S. No.	Treatment	µg/gm (ppm)
01	T0 0–Sec Exposure	0.987 ^d (0)
02	T1 5–Sec Exposure	1.138 ^c (+15.29)
03	T2 15–Sec Exposure	3.289 ^a (+233.23)
04	T3 30–Sec Exposure	2.48 ^b (+107.49)

Each value is the mean of 3 replicates. Values in parenthesis indicate % increase (+) or decrease (-) over control.

Means followed by different letters show a significant result at the level of Standard deviation.

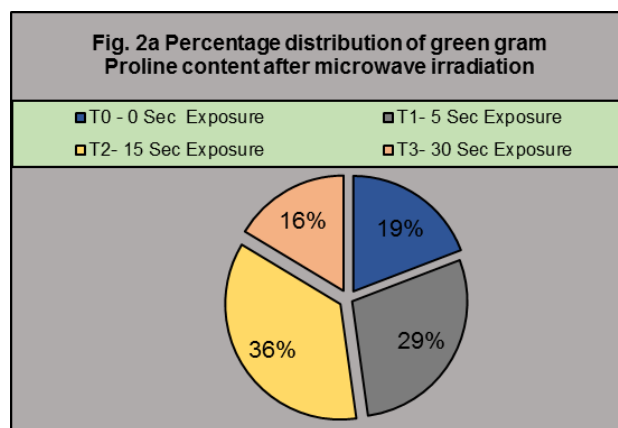


Fig 2a. Microwave radiation effect on proline content of green gram.

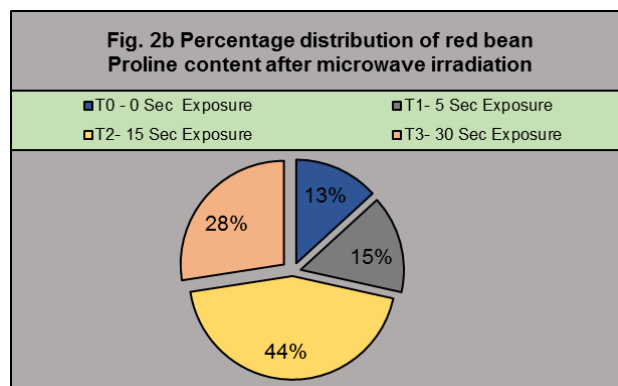


Fig 2b. Microwave radiation effect on proline content of red bean.

CONCLUSION

Seeds of green gram (*Vigna radiata* . L) and red bean (*Phaseolus vulgaris*. L) were subjected to microwave radiations to evaluate their effect on seed germination measurements and seedling vigour. The effects of

differential exposure of microwave radiation were appeared as a triggering factor for germination parameters and seedling vigour (proline as a defense chemical) of both plants, especially within 5 to 15 sec exposure. However, a decrease in germination rate was observed at 30 sec exposure only with red bean seed, whereas the germination percentage of both plant seed increased in all microwave exposure time periods (5, 15 & 30 sec). A similar observation was also observed with proline that found high in both plants' seedling at 15 sec exposure treatment. In the final conclusion, the given investigations of the microwave effects on seed germination and plant physiological functioning clarify the process of energy exchange and thus stimulation of plant growth.

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LIST OF ABBREVIATIONS

AOSA	Association of Official Seed Analysts
EM	Electromagnetic
GRI	Germination Rate Index
I%	Inhibition Percentage

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