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Investigation of the Effect of Microwaves on Mustard Seeds Fertility

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Abstract: With the growth of technology and increase in demand of cellular services day by day; mostly operated at 945 MHz, the presence of microwaves in environment is also increasing. Microwaves are electromagnetic waves with wavelengths ranging from as long as one meter to as short as one millimetre, or equivalently, with frequencies between 300 MHz and 300 GHz. Microwaves may have both positive and negative effects on crops. This paper proposes a technique to enhance the growth rate of crops; particularly mustard plants or sarsu (Brassica seeds). The investigations were carried out with mustard seeds exposed to microwaves for different durations and power levels. The growth of the plants was studied for ten days. The other control variables such as temperature, humidity, sun light and level of gases (CO_2, N_2, and O_2) were maintained almost constant for all the observations. The analysis of the results shows that seeds exposed for proper duration and power level show better growth rate in comparison to the natural growth procedure.

Keywords: Soil, microwave (MW) effects, Brassica seeds.

I. INTRODUCTION

Wireless telecommunication devices increased the exposure of radio and microwave frequencies in the environment. Depending on the power level, frequency, exposure duration, pulsed or continuous wave can damage the exposed tissues [1]. The use of mobile communication motivated the researchers to study the effect of microwave on the health of living organisms [2]. Recent studies show that microwave has a long term effect on living things. Microwaves have ability to produces changes in the cell membrane's permeability. It also affects the cell growth rate as well as interaction with ions and organic molecules, like proteins. In our ecosystem, plants which are grown from seeds are essential components of a healthy diet. They play an important role for living beings, as they are the primary producers of food and oxygen. Therefore it would to necessary to investigate their interaction with increased exposure to radio and microwave frequencies [3]. Microwaves are non ionizing radiations which are the part of the electromagnetic spectrum. The energy content of the electromagnetic (EM) waves are related to the frequency

$$E = hf$$

where E = Electric field, h = plank constant, and f = frequency. EM wave consists of electrical and magnetic field components vibrating in phase and perpendicular to direction of propagation. These waves differ depending upon frequency or wavelength. Frequency and wavelength are related by following equation

$$\lambda = \frac{c}{f}$$

where $c = 3\times10^8 m/s$ is the speed of EM wave in vacuum. Mathematically all waves can be represented by equation given below [4]

$$Y(x,t) = A\cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda + \phi_0}\right)$$

where A is the amplitude of the wave, T its time period, λ the spatial wavelength, and ϕ_0 the reference phase.

Microwaves also affect soil moisture, which is an important component of the hydrology of land surfaces.[5]. Guyadin investigated the effect of microwaves treated water, seeds, and soil on growth of the plants using wheatgrass seeds. He microwaved the water, seeds, and soil for different amounts of time starting from 15 s and doubling the time

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until four minutes. It was reported that microwaved water helped in the growth of the plants. Microwaved seeds resulted in lesser growth. No concrete conclusion could be drawn with microwaved soil [6].

Aladjadjiyan investigated the influence of microwave irradiation on the development of lentil seeds (Lens Culinaris). A magnetron OM75P emitting radiation with frequency 2.45 GHz was used as a source of microwaves for the experiment. The exposure time varied as 0 s, 30 s, 60 s, 90 s, and 120 s. The germination energy and germination of seeds in %, as well as the length of stems and roots in mm at 7^{th} and 14^{th} day after sowing, and the total weight at 14^{th} day were measured to estimate the influence of microwaves. Positive growth rate was reported for exposure time of 30 s and microwave power of 450 w [7].

In [8], investigations were carried out to study the effects of microwaved water and its influences on dissolution of free drugs and drugs in calcium-cross linked alginate beads using sulphanilamide and sulphamerazine as hydrophilic and hydrophobic model drugs, respectively. The water was treated using microwaves at 300 w. The drug dissolution, pH, and molecule mobility profiles of untreated and microwaves treated water were investigated. Microwaves treated water had higher pH and molecular mobility. The latter was characterized by higher conductivity, lower molecular interaction, and crystalline profiles. The untreated water of the same pH as microwaves treated water did not enhance the drug dissolution. The drug dissolution from beads was increased by higher water uptake leading to matrix erosion and pore formation using microwaves treated water and was not promoted by the formation of non-cross linked hydrated agonic acid matrix in untreated water of lower pH. Microwaves treatment of water increased water molecular mobility and could promoted drug dissolution [8].

Brassica and its germination rate has been observed under various natural environmental factors [9]. Although, it is very useful food and medicinal plant [10], the effect of microwaves on its seeds has not been reported yet. Brassica appears in some form or the other in African, Indian, Chinese, Japanese, and Soul food cuisine [11]. In order to acquire high quality raw material from plants and increase crops, there is a scope for improvement in its quality. The objective of this paper is to investigate the changes in growth rate and germination of Brassica seeds after exposed to different amount of microwaves power level and duration. Section 2 provides a brief introduction of seeds and their properties. Section 3 explains the methodology of the investigations followed by results and discussion in Section 4 and conclusion is in Section 5.

II. Seeds

Seeds contain everything necessary for the growth and development of a new plant. The three primary parts of a seed are the embryo, endosperm, and seed coat. The embryo is the young multi cellular organism before it emerges from the seed. The endosperm is a source of stored food, consisting primarily of starches. The seed coat consists of one or more protective layers that encase the seed. The mature embryo consists of an embryonic root known as the radicle, an embryonic shoot, or plumule, and one or two cotyledons. The cotyledon is described as a seed leaf that stores food in the form of starch and protein for use by the embryo. An embryo of a monocotyledon (monocot) plant has one cotyledon, while that of a dicotyledon (dicot) plant has two cotyledons. Brassica are part of oil seed family and are regarded both as a spice and as oilseeds. The Brasscicaceae family consists of approximately 375 genera and 3200 species of plants, of which about 52 genera and 160 species are present in Australia. It is one of the most ancient spices and is cultivated throughout India, especially in Bihar, Bengal, and Uttar Pradesh. It has mainly three varieties namely black, brown, and white. The black Brassica plant normally grows to a height of 10 feet, the brown Brassica is largely cultivated and produces tiny yellow colored flowers, while the white Brassica is the most mild among all the varieties of Brassica. Brassica seeds are shown in Fig. 1 and its leaves in Fig. 2.

Brassica seed has a fresh aroma and slightly biting flavour but they give fragrance when the seeds are dried. The leaves, the seeds, and the stem of it are edible. Brown Brassica is used for medicinal purpose as well as for food, since centuries. It is known with different names in different regions like; mustard in English; Lal Sarsu in Hindi; Rai in Gujarat, Punjabi, and Hindi again; Avalu in Telgu; and Mohari in Marathi. The growth of the seeds depends upon many factors. The arrangement and size of soil particles plays a very important roll. Soils are classified into 12 types and they are arranged in a triangular form and the triangle is known as Soil Texture Classification Triangle [13]. They specify the amount of pores and their distribution. The emission of thermal microwave radiation from soil depends on the soil moisture content [14].

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Fig. 1. Brassica seeds [12].

Fig. 2. Brassica leaves [15].

III. METHODOLOGY

A household type microwave of 650 w; with energy at high power supplied by magnetron operating at 2450 MHz in the Continuous mode, was used to carry out this study. The energy output into the microwave oven capacity was determined by measuring the rise in temperature of 100 ml of distilled water, with initial temperature 24^{o}C in a Borosil glass beaker, placed at the centre of the cavity and heated continuously at full power for 90 seconds. The following relation may be used for estimating the power

$$P = C_p K \Delta T (m / t)$$

where P is the apparent power absorbed by the water sample (J s^{-1}), C_p is the heat capacity of water (J ml^{-1} ^{o}K^{-1}), K = 4.184 is a factor to convert thermal chemical cal ml^{-1} ^{o}K^{-1} to watts (J s^{-1}), ΔT (^{o}C) is the difference between initial temperature and final temperature of water, m is the mass of water (g) and t is the duration of microwave energy application.

The Brassica seeds were exposed for different durations of 30 s, 60 s, 90 s, 120 s, 150 s and microwaves power levels of 30 w, 50 w, 70 w, 90 w. The exposed seeds were sown in different pots and kept under control conditions for ten days. Each sample was observed with respect to change in length. Experimental setup is shown in Fig. 3 and the procedure for measuring the length of the plant in Fig. 4.

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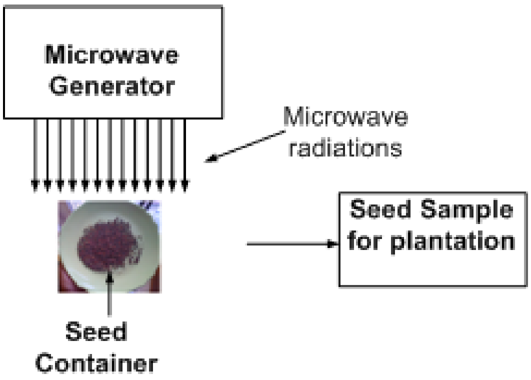

Fig. 3. Experimental set up.

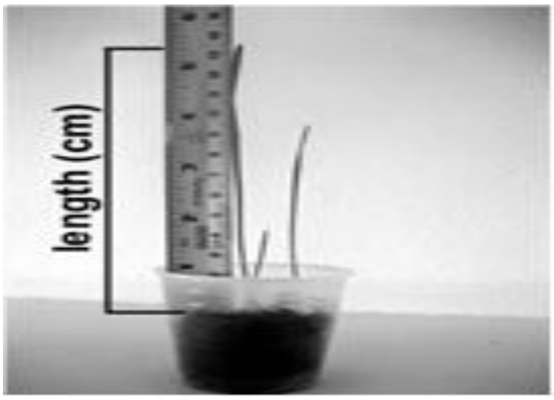

Fig. 4. Measuring the plant length.

IV. RESULTS AND DISCUSSION

The results of measurements of the length of the plants are shown in Table I and Table II. The same results are also plotted in Fig. 5 and Fig. 6. These values were taken as mean values of the length of ten plants grown in each pot. As the exposure duration increases at power levels 30 w to 70 w, increase in length of plant is observed up to 60 s. For exposure durations more than 70 s, the microwaves affect the seeds very badly. If the power of the microwaves is increased above 70 w, the seeds do not grow properly. The image of the plants in initial state is shown in Fig. 7 and the image for the final state is shown in Fig. 8.

Table I. Length of the microwaved seeds after five days of germination with different exposure durations and power levels.

Time (s)	Power (30 w)	Power (50 w)	Power (70 w)	Power (90 w)
30	7.0	4.8	3.1	2.9
60	7.5	5.0	3.7	0.5
90	6.7	5.0	3.1	0.8
120	5.0	4.3	0.0	0.7
150	5.0	6.2	0.0	0.0

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Table II. Length of the microwaved seeds after ten days of germination with different exposure durations and power levels.

Time (s)	Power (30 w)	Power (50 w)	Power (70 w)	Power (90 w)
30	9.0	6.8	5.0	5.0
60	11.5	7.0	5.5	2.0
90	9.5	7.0	5.0	2.5
120	7.0	6.8	0.0	2.7
150	7.0	8.0	0.0	0.0

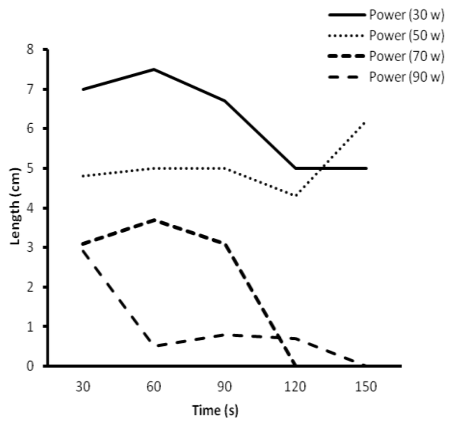

Fig. 5. Variation of length of plant with exposure duration and power level after 5 days.

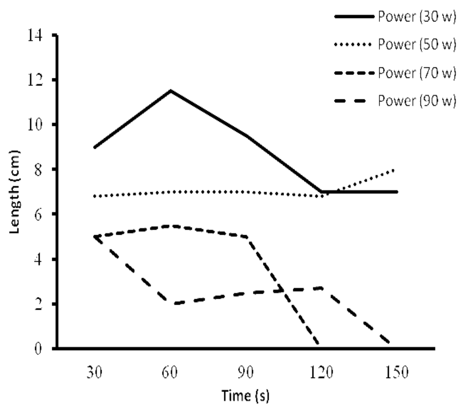

Fig. 6. Variation of length of plant with exposure duration and power level after 10 days.

Fig. 7. Image of the initial state of the plants.

Fig. 8. Image of the final state of the plants.

V. CONCLUSION

Investigations were carried out to study the effect of microwaves on the growth rate of Brassica seeds. The seeds were exposed to microwaves at different power levels and exposure durations. The analysis of the results showed that power level below 90 w with exposure time around 60 s helps in growth of the plants. Above 90 w or more than 60 s exposure duration hampers the growth. The results may be useful for enhancing the crop production of these plants.

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BIOGRAPHY

Er. Akhil Gupta received his B.E. degree in Electronics and Communication Engineering from Model Institute of Engineering and Technology, Kot Balwal Jammu (J&K) affiliated to Jammu University, Jammu (J&K). He is presently doing M-Tech in Electronics and Communication Engineering from Sri Sai College of Engineering and Technology, Pathankot (Punjab). His fields of interests are microwaves and mobile communication. He did one month training of radio frequency drive test in mobile communication.

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Mr. Jang Bahadur Singh is pursuing PhD in biomedical signal processing in the department of Physics & electronics, University of Jammu under the guidance of Dr. Parveen Lehana. His research interests include speech, biomedical signal processing, robotics, and microwaves. He has more than 10 publications.

Dr. Parveen Lehana received his Master's degree in Electronics from Kurushetra University in 1992 and qualified UGC-CSIR-NET-JRF in Physical Sciences and Electronics. He joined University of Jammu in 1994 as assistant professor. Presently, he is working as Associate Professor in Physics and Electronics Department, University of Jammu. He did his research from IIT Bombay in the area of signal processing. He has good experience of guiding M.Tech., M.Phil., and Ph.D. students. He has more than 100 research papers to his credit. He fields of interests are speech signals processing, computer vision, nanotechnology, and microwaves.