Effect of Microwaves Treated Soil on Growth of Mustard Plants

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***Abstract*—Over the past few decades with the growth in cellular services all over the world; a noticeable observation comes in front regarding the life span of birds and growth of crops. This is because of obvious reason of increase in microwave presence in our atmosphere. The cellular phones mostly work at 945 MHz frequency. The objective of this study is to investigate the changes in growth rate and germination of mustard plants after exposure of different amount of microwaves in power and duration. The observations for a period of ten days using microwaves treated and untreated soul were carried out. The other control variables such as temperature, humidity, sun light and level of gases (CO_2, N_2, and O_2) were maintained almost same for all the observations. The investigations have shown that the plants grown with microwave exposed soil behaved differently.**

***Index Terms*— Mustard, microwave (MW) effects, soil.**

I. INTRODUCTION

Over the past few decades with the growth in cellular services all over the world; some noticeable counterproductive effects have been observed on the growth of crops. This is may be because of increase in microwave energy present in our atmosphere. The cellular phones mostly work at 945 MHz frequency [1]. Although several plants and seeds are frequently used in kitchen, mustard appears in some or the other form in most of the countries like Africa, India, China, and Japan [2]-[4]. It is also 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 mustard plant normally grows to a height of 10 feet. The brown mustard is largely cultivated and produces tiny yellow flowers. White mustard is the mildest among the above varieties. Because of extensive use of mustard, it has high commercial value. Mustard seed has a fresh aroma and slightly biting flavor. Dried seeds of mustard give a unique fragrance. The leaves, the seeds, and the stem of mustard are edible. Since centuries, the brown mustard is used for medicinal purpose also. It is known with different names in different regions like; mustard in English, Lal Sarsu in Hindi, Rai in Gujarati, Punjabi, Avalu in Telgu, and Mohari in Marathi. Mustard oil is also used for massage purposes. It is said to improve the blood circulation and muscular strength. It aids in reducing the effects of arthritis and also detoxifies the body from harmful substances. Mustard oil is used as flavoring in food processing industry and it will also denature alcohol.

The systematic exploration of mustard plant; having botanical name as Brassica Juncea and common name as Sarsu in north India, belongs to a family Brassicaceae.

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Its germination rate has been observed under various conditions varying from natural environmental factors and other environmental passive factors. One of the next aims in the study of complex mustard seeds must be to understand its behavior under a very important factor present within environment i.e. microwaves which is increasing its presence in daily routine life of humans. In the recent years, an increasing number of global soil moisture products have become available from passive and active coarse resolution satellite microwave sensors. This seed was chosen because the plant can be conveniently grown and handled in the laboratory, and it is a representative of a family of important vegetables and finds its use in almost all Indian kitchens and various medicines too.

Microwave emission from crops can be featured by long vertical structures. It has been examined by using experimental facts at 10 GHz and 37 GHz which was then modeled by the Radiative Transfer Theory. The effects on the total emission from crops were estimated by means of measurements carried out on plants in natural conditions. The results were concluded by means of emission and scattering properties of the crop. The investigation of optical depth and single-scattering albedo on plant water content has also been studied [5].

Guyadin investigated the effect of microwave treated water, seeds, or soil on growth of the plant. He used wheatgrass seeds in each container because they grow fast and provide results in a few weeks. He microwaved the water, seeds, and soil for different amounts of time starting at 15 seconds and doubling the time until four minutes. This gave us proper results because with more than one time, you can see the difference and compare the results to the control. He controlled everything except the time of microwaving the seeds, soil, and water, so the results did not change because of other factors. For the water condition, all the plants grew and microwaving made the plant grow faster and increased the length. For the seed condition, microwaving the seeds caused the plants to decrease in sprouting percentage, and as the microwave duration was increased, the length of the plant was decreased. For the soil condition, the length, the sprouting, and the day of first emergence showed random behavior [6].

Aladjadjiyan investigated the influence of microwave irradiation treatment on the development of lentil seeds (Lens Culinaris, Med.). A magnetron OM75P (31) emitting radiation with frequency 2.45 GHz has been 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 (GE) and germination (G) of seeds in %, as well as the length of stems (SL) and roots (RL) in mm at 7^{th} and 14^{th} day after sowing, and the total weight (TW) at 14^{th} day have been measured aiming to estimate the influence of microwave treatment. Best results have been obtained for variants with exposure time 30 s and output power 450 w. SL measured at 7^{th} day was 10% longer than the control one, RL = – 7%, and TW at 14^{th} day was 16% higher [7].

Interest in controlling weed plants using radio frequency or microwave energy has been growing in recent years because of the growing concerns about herbicide resistance and chemical residues in the environment. This paper reviews the prospects of using microwave energy to manage weeds. Microwave energy effectively kills weed plants and their seeds; however most studies have focused on applying the microwave energy over a sizable area, which requires about ten times the energy that is embodied in conventional chemical treatments to achieve effective weed control. A closer analysis of the microwave heating phenomenon suggests that thermal runaway can reduce microwave weed treatment time by at least one order of magnitude. If thermal runaway can be induced in weed plants, the energy costs associated with microwave weed management would be comparable with chemical weed control [8].

Ground-based polar metric scatter meters have been effective tools to monitor the growth of rice crop, with much higher temporal resolution than satellite synthetic aperture radar systems. However, scatter meter data obtained in every few days, as were the case for the previously reported studies, were not enough to address the effects of ever-changing weather conditions. In [9], a highly stable X-, C-, and L-bands polar metric scatter meter system in an air-conditioned shelter. The incidence and azimuth angles of the antenna were fixed to 40◦ and 0◦, respectively, to avoid uncertainty in repositioning error. Season-long daily backscattering coefficients from transplanting to harvesting were compared with rice growth data. Total fresh weight, leaf area index, and plant height were highly correlated with L-HH (0.97, 0.96, and 0.88, respectively) due to the deeper penetration and the dominance of double bounce in lower frequency. High-quality backscattering data clearly revealed the dual-peaked pattern in X-band, among which X-VV correlated best with grain dry weight and gravimetric grain water content (0.94 and 0.92, respectively) due to the better interaction of grain and rice canopy with microwave of higher frequency. These results will be useful in retrieving crop biophysical properties and determining the optimum microwave frequency and polarization necessary to monitor crop conditions [9].

The influence of cold plasma treatment on a germination enhancement of wheat and oat caryopses in wider context has been studied. Wheat and oat corns have been stimulated by cold plasma discharge under power of 500 w, air gas flows of 200 ml/min for different time durations (from 0 to 2400 s). Wheat seed coat showed an eroded surface after plasma treatment. Plasma treatment inhibited the germinating acceleration of wheat in first days but enhancement of footstalk was observed on plants grown from seeds treated for medium time. On the other hand, plasma treatment did not affect germination of oat seeds, but accelerated the rootlet generation at plants grown from treated seeds. The different content of phenol compounds between control sprouts and sprouts from treated seedlings was observed. The different contents illustrated changes in metabolism processes in both tested species. These phenomena indicate penetration of active species from plasma through the porous seed coat inside the seed where they react with seed cells [10].

The effect of microwave radiation on dry soil has been studied. Five different soil samples are collected from various geographical regions of India. The waveguide cell method was employed for the determination of the storage factor and los factor of the soil. The methodology of dielectric constant for unexposed and exposed soils to microwave radiation was given and results obtained were concluded [11].

A microwave system can be used as an alternative method to methyl bromide to control rice storage pests. Four rice varieties grown in Spain were irradiated with three levels of microwave energy (0, 70, and 100 J g–1). Rice quality attributes were analyzed to establish hypothetical quality changes in order to use microwave energy as an alternative method to control pests. Results of the factorial analysis showed that the analyzed attributes differed more within varieties than among microwave treatments of the varieties, except for 'Thainato' which, after applying microwave energy of 100 J g^{-1}, presented a different adhesiveness from the other two treatments determined by factor 1 and 'Puntal' treated with microwaves presented a different water uptake and loss of solids in cooking water determined by factor 3 than the control. The increase in hardness and decrease in adhesiveness as a consequence of the microwave treatment could possibly damage rice quality. This aspect must be taken into account with this method. In conclusion, microwave energy can be used as an alternative method of insect control because it does not seriously affect rice quality. Microwave treatments did not leave undesirable residues and could be as effective at controlling insect infestation as any procedure currently available [12].

The study investigated the effects of microwave on 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 by microwave at 300 w or without pre-treatment. The drug dissolution, pH and molecule mobility profiles of untreated and microwave-treated water were examined. Microwave-treated water had higher pH and water molecule mobility. The latter was characterized by higher conductivity, lower molecular interaction, and crystalline profiles. The dissolution of hydrophilic and hydrophobic free or encapsulated drugs was enhanced using microwave-treated water due to its higher molecular mobility. The untreated water of the same pH as microwave-treated water did not enhance drug dissolution. The drug dissolution from beads was increased by higher water uptake leading to matrix erosion and pore formation using microwave-treated water and was not promoted by the formation of non-cross linked hydrated agonic acid matrix in untreated water of lower pH. Microwave treatment of water increased water molecule mobility and can promote drug dissolution [13].

The objective of this paper is to investigate the changes in growth rate and germination of mustard plants after exposed to different ranges of microwaves treated soil. Section 2 provides a brief introduction of soil. Section 3 explains the methodology of the investigations followed by results and discussion in Section 4 and conclusion is in Section 5.

II. SOIL

Soil is composed of solids, liquids, and gases mixed together in variable proportions. The relative amount of air and water present depends on the way the soil particles are packed together. The structure of soil depends on the way the particles are arranged and also on the size of the particles [11]. They specify the amount of pore space and its disturbance in the soil. The emission of thermal microwave radiation from soil depends on the soil moisture content [14]. Soils are classified into 12 types and they are arranged in a triangular form and I known as Soil Texture Classification Triangle [11].

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 ^oC in a Borosil glass beaker, placed at the center of the cavity and heated continuously at full power for 90 seconds; and can be calculated using following equation as proposed by Neas and Collins in 1988. Using this equation, the microwave oven output was calculated as 640 W (J s^{-1}).

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

where *P* is the apparent power absorbed by water sample (J s^{-1}), C_p is the heat capacity of water (J ml^{-1} $^oK^{-1}$), K = 4.184 is a factor to convert thermal chemical cal ml^{-1} $^oK^{-1}$ 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.

III. METHODOLOGY

For the investigation of microwaved soil on the germination of brassica seeds is described here. Brassica seeds used in the experiment are of hybrid quality purchased from local street market. The soil prepared for the experiment undergoes exposure of microwave for different wattages and time durations. The block diagram of the experiment is shown in Figure 1. This sample of agricultural soil was collected with total organic C ranged from 4.6 to 32.9 g kg^{-1}, clay content ranged from 1.07 to 1.48 g cm-3 bulk density ranged from 1.07 to 1.48 g cm^{-3} and pH ranged from 4.8 to 7.5. The wattage varied in steps from 30, 50, 70 and 90 watt whereas time varied from 30, 60, 90,120 and 150 seconds. It is important to note that only soil is exposed to microwave while seeds and water remains unaffected a shown in Figure 2. To carry out this experiment, we take sample of agriculture soil in twenty different cups. Each cup of soil is microwaved to different wattages and durations, depending upon the configuration described in Table I. Ten seeds germination was observed after 5 and 10 days of interval as shown in Figure 3 and Figure 4. Specimens were kept under natural environmental conditions. Each sample is kept under observation for ten days and a noticeable change in the length of plants growth was observed varied as per the microwave effect.

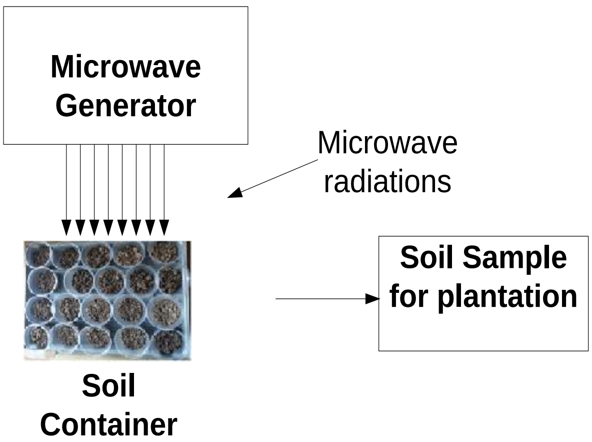

Fig. 1. Block diagram of the experiment.

IV. RESULTS AND DISCUSSION

The change in length of plant is tabulated in the form of tables. Results are displayed in Table I and Table II. The images of the plants are shown in Figure 2 to Figure 5. For visual interpretation, the results of Tables are also plotted in Figure 6 and Figure 7.

Table I. Length of the microwaved soil after five days of germination at different time and wattages.

Time (s)	Power (30 w) (cm)	Power (50 w) (cm)	Power (70 w) (cm)	Power (90 w) (cm)
30	1.7	4.8	4.6	6.8
60	1.5	4.5	3.6	7.6
90	3.1	4.5	3.5	7.2
120	1.3	4.1	5.6	6.5
150	2.4	4.5	3.9	5.9

Table I shows that as we increase the exposure time at power 30 w, there is decrease in length of plant. In the middle it reaches the highest value that is 3.1 cm, and after it again decreases and reaches to 2.4 cm. In case of 50 w, the value remains almost constant that is approximately 4.5 cm. In case of power 70 w, the starting value is 4.6 cm, and in middle value decreases and again rises and in the last value falls to 3.9 cm. In case of 90 w, the best result is obtained, value fall only upto 5.9 cm. It may be concluded that the time 60 seconds and wattage 90 w is the best level of exposure for maximum growth after five days.

Table II shows that as we increase the exposure time at 30 w, there is decrease in length of plant and in the middle it reaches the highest value that is 8.5 cm, and after it again decreases and reaches to 6.6 cm. In case of 50 w the value remain almost constant that is approximately 6.5 cm. In case of 70 w, the starting value is 8 cm, and in middle value decreases and again rises and in the last value falls to 5.3 cm. In case of 90 w, the best result is obtained giving the height of the plants around 7.4 cm. It may be concluded that the exposure time of 30 seconds and at 90 w is the best exposure level for growth of the plants after ten days.

Table II. Length of the microwaved soil after ten days of germination at different time and wattages.

Time (s)	Power (30 w) (cm)	Power (50 w) (cm)	Power (70 w) (cm)	Power (90 w) (cm)
30	4.5	6.5	8.0	10.0
60	3.5	6.5	5.2	9.8
90	8.5	6.5	5.5	9.0
120	3.3	6.0	7.0	7.4
150	6.6	6.0	5.3	7.0

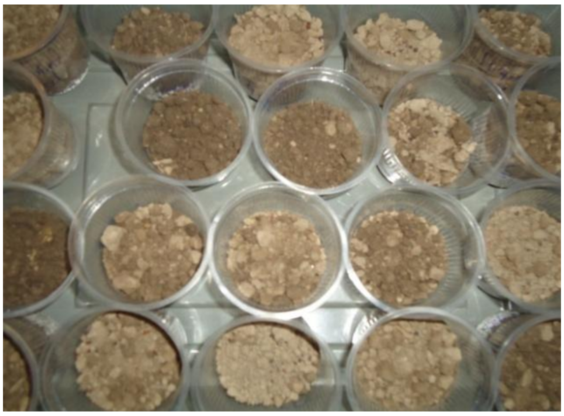

Fig. 2. Microwaved soil germination of seeds at different time and wattages.

Fig. 3. Microwaved soil germination of seeds after five days at different time and wattages.

Fig. 4. Microwaved soil germination of seeds after ten days at different time and wattages.

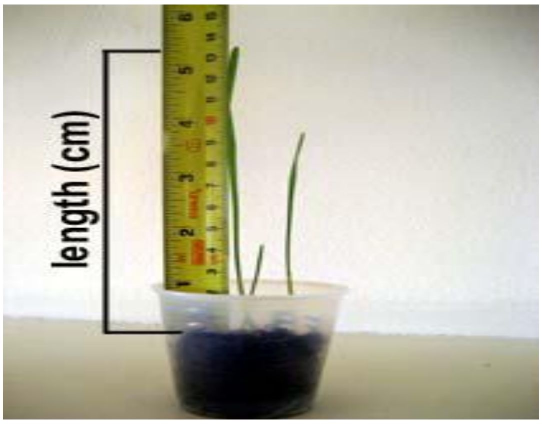

Fig. 5. Measurement of plant length.

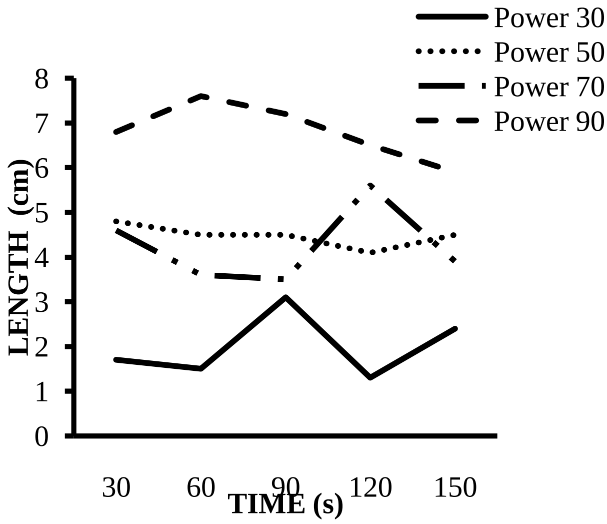

Fig. 6. Graph shows that the length of plant at different time and wattages after 5 days.

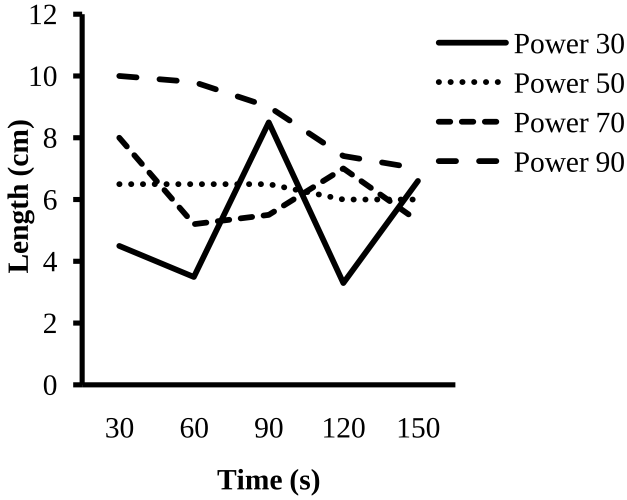

Fig.7. Graph shows that the length of plant at different time and wattages after 10 days

V. CONCLUSION

Investigations were carried out to study the effect of microwaved soil on the growth of mustard plants. Mustard seeds were chosen because they grow at much faster rate and thus provide results in few days. The soil was microwaved for different exposure times ranging from 30 -150 seconds and exposure levels ranging from 30-90 w. Analysis of the results showed that the exposure level of about 90 w and exposure time in the range of 30 s to 60 s helped in growth of the plants.

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