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# The Germination Activation of Pumpkin Seeds by Microwaves

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**Abstract:** The effect of microwave technology at a frequency of 8GHZ was studied on the germination of pumpkin seeds soaked with water for 24 hours and on dry pumpkin seeds to stimulate and activate them through physical cultivation and for different times (5, 10, 15, 20) minutes and compared with the group of seeds that were not exposed to microwaves as (CONTROL) and check to see which is better. The results showed that the soaked seeds were preferred to the dry seeds, regardless of the exposure time. The results of microwave exposure on the soaked seeds also indicated that it had a superiority of the exposure period (15) min over the rest of the exposure periods for the root length characteristic compared with the control. The time (10) min also exceeded the exposure times for the stem length characteristic compared with the control for the soaked seeds and the exposure time exceeded ( 5) min for the characteristic of the number of leaves for the soaked seeds. At the same time, the effect was negative on the dry seeds with the three measured characteristics, which led to an increase in the percentage of inhibitors in the seeds of plants.

**Keywords:** microwaves, physical Agriculture, pumpkin seeds, biological physics.

## 1. Introduction:

Pumpkin plant (Cucurbita pepo L) is a popular summer vegetable crop in Iraq. It belongs to the Cucurbitaceous family, which is commonly cultivated in Iraq[1].Its importance comes from being a human food rich in nutrients and vitamins, in addition to its medicinal uses [2].Given the importance of these plants, they were used in our study based on a study (World Resources Institute in 2012), which concluded that the world population is expected to increase to approximately 9.5 billion people in 2050, and this may constitute a major challenge in order to meet humanity's need for food. The processes of accelerating or stimulating the growth of plant seeds became a matter for scientists. Previously, many toxic and harmful chemicals were used to increase the productivity of plants, which prompted scientists and researchers to come up with alternative, safer and healthier non-traditional ways to increase agricultural production and be environmentally friendly and economical in production. Among those technologies are a non-thermal microwave, which is considered an innovative and safe solution to increase agricultural production and provide food, and they have many advantages in agriculture [3]. As agriculture faces many problems with diseases and pathogens, although there are methods and chemicals for treatment, these materials and methods are not recommended because they are not safe. The physical technique (microwaves) has shown a positive effect in controlling plant diseases caused by pathogens[4].Recently, the increase in the use of electromagnetic waves, especially with the widespread use of wireless communication tools, led to a rise in soil exposure to electromagnetic fields. To investigate this effect, microwaves' non-thermal biological effects on plant tissue responses were determined [5],[6]. As the microwave is part of the family of the electromagnetic radiation spectrum that includes frequencies from 300 MHz to 300 GHz and short wavelength, and works through absorption at the molecular level to indicate vibrational energy or heat and biological effects and is a technical tool in the treatment of food crops that are vital To increase the nutritional value and productivity of crops because they disrupt the growth of bacteria and other microorganisms[7],[8] While plants are essential components of a healthy ecosystem and have an important role in the living world as major producers of food and oxygen; Therefore, it would be useful to check their exposure to microwaves, given that there is some evidence that microwaves induce changes in the cell membrane depending on cell viability and growth rate, as well as interference with ions and organic molecules, such as proteins, which helps to activate seeds and increase crop yields agricultural [9].The researchers [10], by studying the benefits of irradiating vegetable seeds with high-energy microwave radiation, indicated that there is a stimulating effect on many germination factors (root, stem, ....) and the growth rate by microwave.The researchers[11] used in their study the technique of electromagnetic radiation from the radio MHZ (10-40) and microwave (GHZ2.45) as a treatment for mustard seeds, wheat, soybeans, peas and rice in order to eliminate microorganisms and bacteria, and this was successfully achieved. The researchers [12] also evaluated the physiological effects of microwave radiation on barley (Hordeum vulgare L.). He exposed the barley seeds to eight different periods in the microwave, from 0 to 600 seconds. It was found that the germination coefficients depended on the exposure period, and the results showed an increase in the percentage of germinated seeds after

short periods of microwave exposure with a germination rate of 100%, while the effect of longer exposure periods was to reduce the percentage of germination, germination rates, and different germination indicators.

The aim of this study was to evaluate the effect of the non-thermal microwave for different times (5,10,15,20) minutes on the activation of pumpkin seeds soaked in water for 24 hours with water, and to compare it with the activation of dry pumpkin seeds germination. And compared to those not exposed to microwaves.

## 2. Materials and Methods:

### 2.1 The seeds used

2022 HOGER hybrid pumpkin seeds were used, with a germination rate of 80% and purity of 98%, divided into two parts (seeds soaked in water for 24 hours, and dry seeds).These seeds were irradiated using microwave technology in four groups at different times (5, 10, 15, 20) minutes, and they were grown hydroponically in plastic dishes with a group not exposed to radiation (Control). Pumpkin seeds were chosen in this experiment because of their germination period. The short period does not exceed 45 days, according to what is mentioned in the characteristics of the seeds mentioned by the producing company.9 cm diameter Petri dishes and filter papers were prepared and then, 10 plasma-exposed and unexposed seeds were seeded in each replicate (each Petri dish; 9 cm), according to the inter-paper method. This is consistent with what was done by [13].


Figure 1: The seeds used

a- A group of pumpkin seeds placed in water for 24 hours.
b- Dry pumpkin seeds collection.

### 2.2 Microwave system

The horn antenna system (SARGENT-WELCH SCIENTIFIC,U.S.A) was used, which consists of two devices, one of which is a microwave transmitter and the other a receiver. Where the transmitter was used only in our experiment after calibrating it as the figure(2-a) with the receiver [14], as mentioned by the researcher [15] that the antenna is a means to convert the energy contained in the electrical wires into electromagnetic waves flowing in space. The system was equipped with a transmitter with a power about 100dB and a frequency of 8GHz (i.e. X-band) and was placed at a height of 5cm from the samples as the figure (2-b). The samples were exposed to four groups at different times (5, 10, 15, and 20) minutes to compare the effect with the group of samples that were not exposed to microwave.

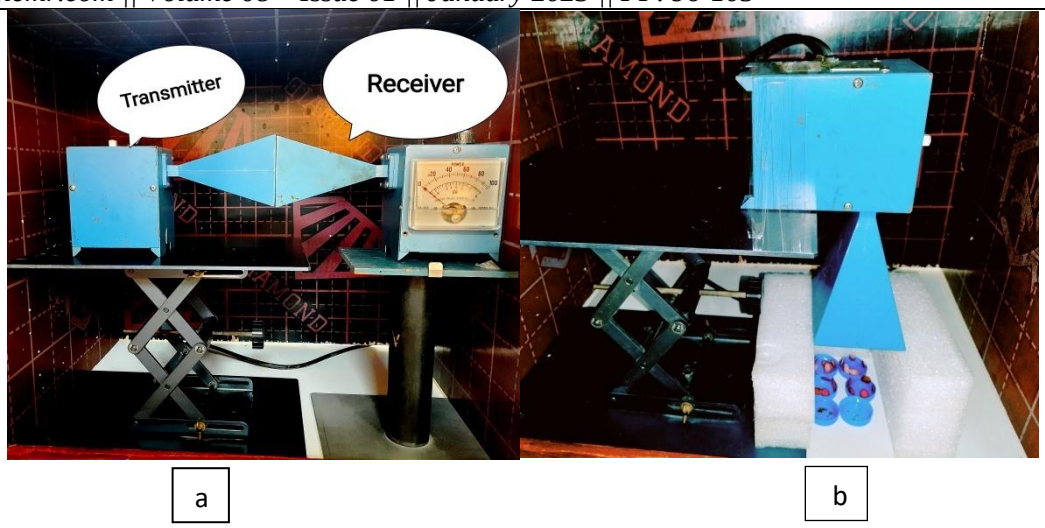


Figure 2: a-The horn antenna system used during calibration in the scientific laboratory
b- Expose the seeds to microwave radiation

### 2.3 The mechanism of the microwave generating

Antennas usually operate in the air or outer space, as the antenna is a set of conductors that are regularly arranged to produce radiating electromagnetic fields as a result of an applied alternating voltage and associated electric current on the transmitter side, while at the receiver the electromagnetic field induces an alternating current that the device can receive for reading as shown in Figure (3). The standard calibration and determination of the relative power were done between microwave receiver and transmitter, both are horns type, with a good directivity and small value of VSWR, so it works with high efficiency[16].

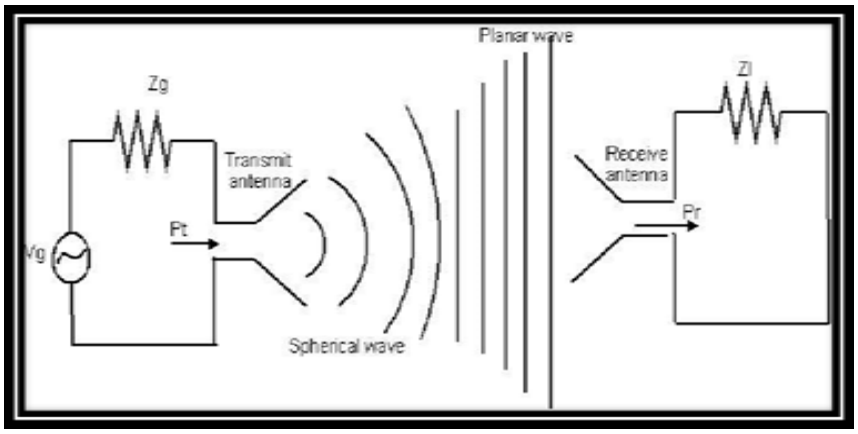


Figure 3: The working principle of the transmitter and receiver antenna[15]

## 3. Statistical analysis

Factor experience- A randomized complete design (R.C.D) was used, with a 2×5 factorial experiment (type of seed treatment × exposure period) and a comparative treatment to analyze the data of the experiment to find out the significant differences between the treated seeds of the two factors and their interactions, Duncan's multiple range test version-9 of the Statically Analysis System (SAS) was used, at the level of probability of ($P < 0.05$), [17],[18].

## 4. Results and discussion

Non-thermal micro-waves affect the tissues and cells of plant seeds, making them more active and vital compared to seeds that were not exposed to these waves, and this agrees with the researchers [19]. This micro-waves increases protein and amino acids, with a decrease in sugars, nucleic acids and phenolic compounds when interacting with plant seeds. This explanation was based on the work of [20].

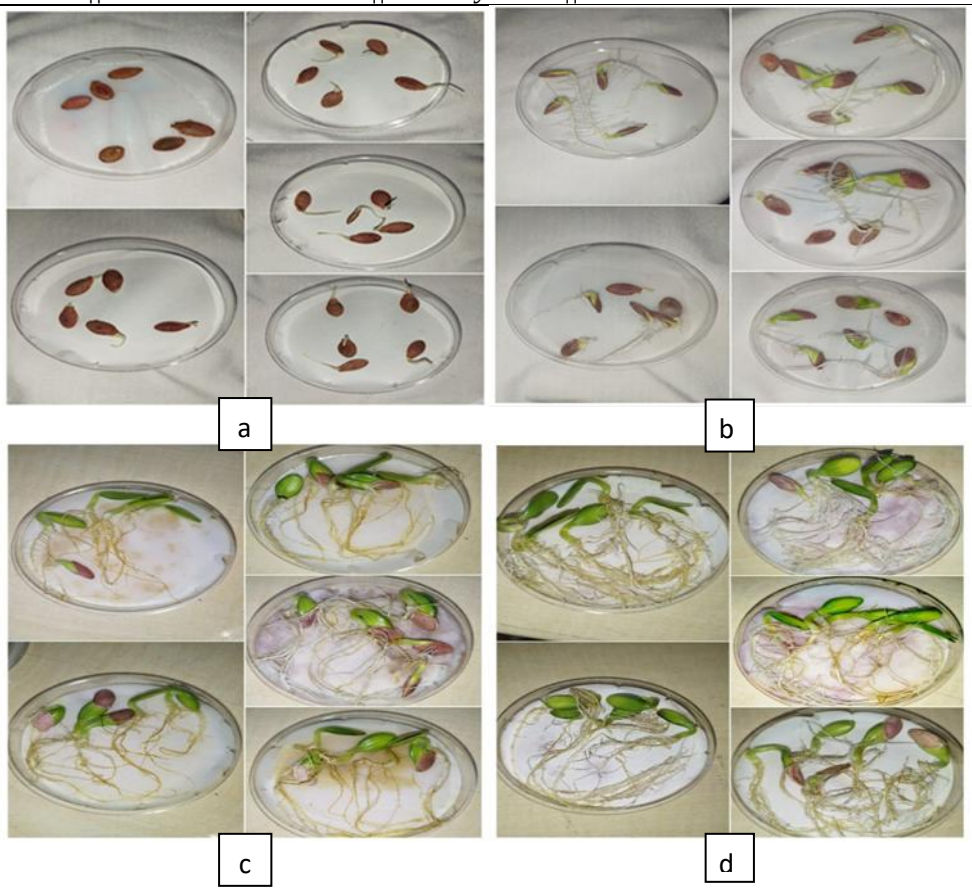


Figure 4: Growth stages of pumpkin seeds exposed to microwave at different times with control seeds over a period of ten days

a- The first day of agriculture
b- The second day of agriculture
c- The seventh day of agriculture
d- The tenth day of agriculture

Table (1):Growth lengths of pumpkin seeds by the effect of exposure to microwaves soaked for 24 hours and dry seeds for different periods of time on root growth for a period of ten days (mean + standard deviation).

| Tenth Day | Eighth Day | Eighth Day | Seventh Day | Sixth Day | Fifth Day | Fourth Day | Third Day | Second Day | First Day | Exposure Times | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 37.99±106.96 a | 37.97±103.02a | 37.9±99.12 a | 38.46±94.59a | 37.31±87.27a | 35.7±74.95 a | 29.45±62.79 a | 26.55±46 a | 19.25±27.38 a | 9.42±11.63 a | **Soaked seeds** | **Seed treatme** |
| 70.34±78.62b | 65.34±75.26b | 60.91±69.68b | 56.29±63.29b | 50.9±54.72 b | 43.21±42.77 b | 30.69±29.56 b | 19.75±18.23 b | 5.86±4.32 b | 0.0±0.00 b | **Dry seeds** | |
| 50.21±124.75 a | 46.17±115.1 a | 42.89±106.12 a | 41.46±96.58 a | 42.5±88.46 a | 39.21±66.77 a | 26.67±53.3 a | 17.37±31.19 a | 10.58±11.19 b | 5.16±2.67 b | **Control** | **Microwave treatment of seeds** |
| 52.91±95.74 ab | 51.13±92.02 ab | 49.9±88.52 a | 48.63±83.72 a | 44.56±76 A | 39.36±64.11 a | 35.17±51.16 a | 28.79±35.94 a | 17.97±15.73 ab | 10.96±8.33 a | **Microwave(5) min** | |
| 60.65±82.19 b | 58.51±77.62 b | 57.4±73.87 a | 55.38±68.45 a | 53.46±60.73 a | 51.52±51.85 a | 40.84±38.55 a | 31.52±28.85 a | 22.01±17.01 ab | 10.25±8.13 a | **Microwave (10)min** | |
| 53.39±85.76 b | 51.59±83.09 ab | 49.49±79.99 a | 48.29±76.71 a | 44.62±69.4 a | 42.52±62.21 a | 35.77±49.55 a | 31.1±38.23 a | 22.36±21.78 a | 10.16±7.74 a | **Microwave (15)min** | |
| 64.19±75.52 b | 62.32±77.88 b | 59.69±73.52 a | 56.75±69.26 a | 49.46±60.37 a | 40.77±49.37 a | 31.71±38.33 a | 25.42±26.35 a | 16.05±13.53 ab | 3.4±2.22 b | **Microwave (20)min** | |
| **The interaction between seed treatment × microwave seed treatment** | | | | | | | | | | | |
| 35.83±107.9 abc | 36.93±101.25 abc | 37.83±96.99 abc | 40.77±89.47 abc | 40.76±81.66 abc | 24.41±51 bcd | 24.41±51 abc | 18.97±31.73 bcd | 13.73±14.44 cd | 6.36±5.33 b | **Control** | **Soaked seeds** |
| 28.92±116.2 ab | 28.82±113.83 ab | 28.92±110.64 ab | 30.04±107.15 a | 26.22±99.88 a | 22.29±88.66 a | 26.47±71.57 a | 25.46±51.64 ab | 17.09±28.59 ab | 9.98±16.65 a | **Microwave (5)min** | |
| 59.03±99.7 | 58.93±97.8 | 58.86±95.3 | 58.36±92.0 | 58.16±86.1 | 56.6±81.59 | 43.32±62.0 | 34.24±45.3 | 21.61±32.6 | 8.66±16.25 | **Microwave** | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 abc | 1 abc | abc | 6 abc | 8 abc | ab | 8 a | 9 ab | 9 ab | a | **(10)min** | |
| 25.24±117.46 ab | 23.56±113.38 ab | 22.03±108.17 ab | 21.82±103.36 ab | 21.93±95.63 ab | 27.89±87.05 ab | 25.32±73.19 a | 25.09±60.28 a | 19.06±38.97 a | 9.21±15.48 a | **Microwave (15)min** | |
| 33.76±93.55 abc | 33.5±88.84 abc | 33.27±84.52 abc | 33.18±80.9 abc | 29.15±72.98 a-d | 26.99±66.47 abc | 22.31±56.11 ab | 22.64±40.94 abc | 17.56±22.22 bc | 3.67±4.44 b | **Microwave (20)min** | |
| 58.36±141.59 ab | 52.05±128.96a | 47.61±115.26a | 43.06±103.69 ab | 45.26±95.27 ab | 45.8±82.53 ab | 29.9±55.6 ab | 16.63±30.64 bcd | 4.94±7.94 d | 0.0±0.00 b | **Control** | **Dry seeds** |
| 64.37±75.27 bc | 60.26±70.22bc | 57.74±66.4 abc | 53.58±60.28 abc | 47.3±52.13 bcd | 37.87±39.55 cd | 31.38±30.74 bcd | 23.54±20.25 cd | 4.77±2.88 d | 4.94±7.94 d | **Microwave (5)min** | |
| 60±64.67 Bc | 53.38±57.43c | 49.7±52.43 c | 42.78±44.84c | 34.79±35.27 d | 20.82±22.1 cd | 20.34±15.01 d | 17.8±12.31 d | 3.11±1.34 d | 4.94±7.94 d | **Microwave (10)min** | |
| 56.12±54.07c | 54.99±52.79c | 54.04±51.80c | 53.56±50.06c | 46.84±43.17 cd | 40.85±37.37 cd | 28.6±25.91 cd | 18.22±16.17 d | 5.97±4.6 d | 4.94±7.94 d | **Microwave (15)min** | |
| 82.68±57.48c | 82.52±66.91bc | 78.39±62.51bc | 73.46±57.61bc | 62.94±47.75 cd | 46.17±32.28 cd | 30.37±20.56 d | 19.45±11.76 d | 8.21±4.84 d | 4.94±7.94 d | **Microwave (20)min** | |

The different letters on the averages of the treatments within the comparison of the seed treatment or the plasma treatments or the interaction between them for each day indicate that there are significant differences ($P<0.05$) between the treatments. Where the results shown in Table (1) showed the effect of non-thermal microwave waves on the root length of the seeds soaked in water for 24 hours, where the average values were taken for ten seeds for each replicate, and it was shown that the seeds placed in water for 24 hours had a preference over the dry seeds by treating the seeds with There were statistically significant differences over the ten days during which the cultivation was carried out, as it was shown through the discussion the preference of pumpkin seeds soaked in water for 24 hours over dry pumpkin seeds. The reason for this is that pumpkin seeds have a very high percentage of inhibitors, and one of its properties is that when washed with water, these inhibitors are removed by 90%, which helps the plasma to activate the seeds and break the dormancy barrier. The interpretation of this agrees with the study of researchers [21].

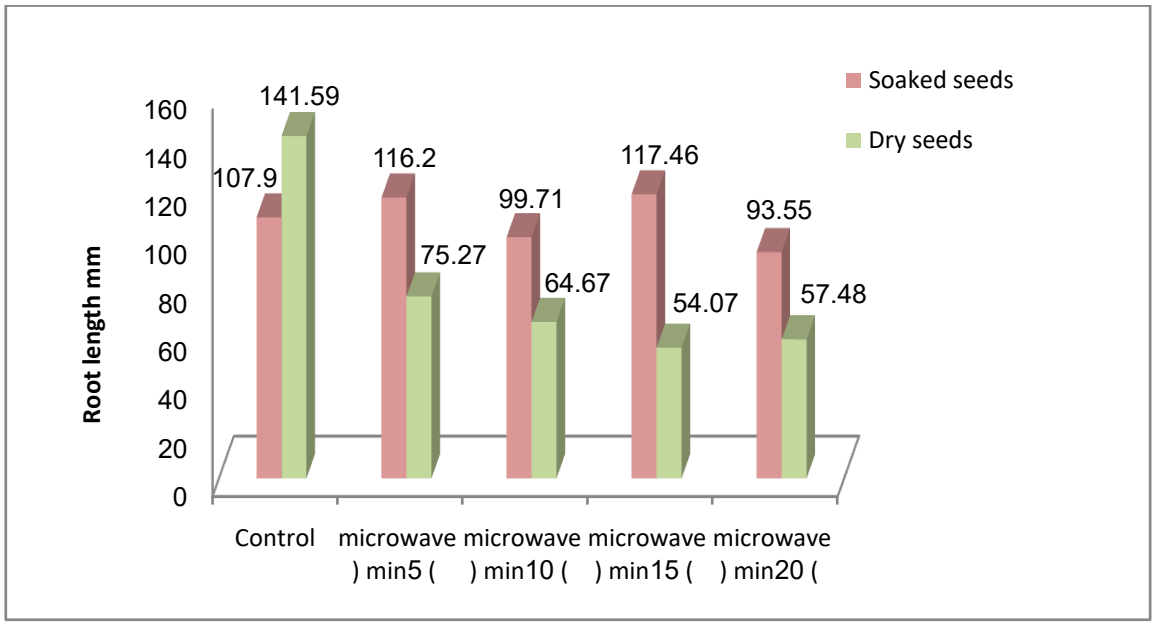


**Figure 5:**Effect of exposing pumpkin seeds to microwave technology at different times (0.5, 1, 3, 5) minutes on root length (mm) for both seeds soaked for 24 hours with water and dry seeds ten days after agriculture.

The results of exposure to microwaves on seeds soaked in water for 24 hours and dry seeds through Figure (4) showed superiority of exposure time of (15 minutes) for seeds soaked with the highest average, where the root length after ten days was (117.46 mm), superior to the average of seeds that did not exposed by 8.9%. This was followed by the exposure period (5min), where the average root length was (116.2mm), outperforming the control by 7.7%. The negative effect of the microwave effect appeared on the seeds soaked for a time of (20) min compared to the control group. This is due to the inhibition of plant growth with the increase in energy resulting from microwave irradiation, and this is consistent with the interpretation of the researchers [22], where their results were interpreted according to the hypothesis that " The larger energy absorbed by molecules with

higher production capacity and longer exposure time can destroy cell functions and the stimulation effect cannot be achieved." Where the non-thermal micro-waves interact with the water molecules in the seed that vibrate inside the seed and help the seed cells activate growth and vital processes, and this is consistent with the researchers' study [23] who mentioned that there is an effect between micro-waves and the unique hydrogen bonds in molecules water. While in the dry seeds, it was found that the effect of micro-waves on the seeds had a negative effect, which made the percentage of growth inhibitors in the seeds increase, which prevents the micro-waves from breaking the dormancy of the seed. 24 hours because when it was soaked, the inhibitors were removed from the seed coat and a reaction occurred between the microwave and the water molecules.

Table (2):shows the effect of microwave exposure on pumpkin seeds soaked for 24 hours and dry seeds for different periods of time on stem growth for ten days (mean + standard deviation).

| Tenth Day | Ninth Day | Eighth Day | Seventh Day | Sixth Day | Fifth Day | Fourth Day | Third Day | Second Day | First day | Exposure Times | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.45+18.93 a | 6.9+17.19 a | 6.49+15.85 a | 6.59+14.31 a | 6.62+12.85 a | 6.71+10.69 a | 5.54+8.93 a | 4.87+6.14 a | 3.39+3.35 a | 0.0+0.00 a | **Soaked seeds** | **Seed treatmen t** |
| 22.02+15.06 a | 9.3+11.05 b | 8.58+9.81 b | 7.88+8.38 b | 6.73+6.39 b | 5.32+4.57 b | 3.78+1.74 b | 2.54+1.13 b | 0.0+0.00 b | 0.0+0.00 a | **Dry seeds** | |
| 4.89+16.18 a | 5.08+15.00 a | 4.83+13.86 a | 5.9+11.88 a | 5.94+10.43 a | 6.00+7.78 a | 5.16+6.7 A | 3.69+4.13 a | 0.0+0.00 c | 0.0+0.00 a | **Control** | **Microwave treatment of seeds** |
| 9.09+16.98 a | 9.29+15.30 a | 8.78+14.19 a | 8.14+12.64 a | 7.69+10.1 a | 7.01+7.86 a | 6.49+5.34 ab | 4.71+3.85 a | 3.12+2.27 ab | 0.0+0.00 a | **Microwave(5) min** | |
| 10.1+15.98 a | 9.74+14.40 a | 9.34+12.68 a | 8.97+11.59 a | 8.72+9.60 a | 8.42+8.34 a | 7.21+5.82 ab | 4.68+3.26 a | 3.24+2.27 ab | 0.0+0.00 a | **Microwave (10)min** | |
| 9.66+15.46 a | 9.53+14.24 a | 8.88+13.04 a | 8.34+11.53 a | 7.73+9.95 a | 6.77+7.85 a | 5.99+5 ab | 6.11+4.38 a | 3.88+2.73 a | 0.0+0.00 a | **Microwave (15)min** | |
| 32.54+20.36 a | 9.44+11.69 a | 8.4+10.37 a | 7.73+9.09 a | 7.12+8.03 a | 5.84+6.34 a | 4.78+3.84 b | 3.67+2.56 a | 1.98+1.09 bc | 0.0+0.00 a | **Microwave (20)min** | |
| **The interaction between seed treatment × microwave seed treatment** | | | | | | | | | | | |
| 5.25+15.78 a | 6.01+14.37 ab | 5.8+13.28 ab | 5.54+12.09 abc | 5.91+9.94 abc | 5.58+5.7 cde | 5.58+5.7 d | 4.07+3.14 cd | 0+0 c | 0.0+0.00 a | **Control** | **Soaked seeds** |
| 3.51+19.84 a | 3.72+18.62 a | 3.76+17.87 a | 3.94+16.22 ab | 4.36+14.95 a | 5.89+12.62 ab | 5.06+10.69 ab | 3.73+7.7 ab | 3+4.55 a | 0.0+0.00 a | **Microwave (5)min** | |
| 9.16+21.11 a | 8.4+19.5 a | 7.66+17.94 a | 7.95+16.72 a | 7.72+15.29 a | 7.75+14.23 a | 5.86+11.64 a | 4.77+6.51 ab | 3.28+4.54 a | 0.0+0.00 a | **Microwave (10)min** | |
| 4.71+20.53 a | 5.39+19.05 a | 5.54+17.43 a | 6.38+15.46 ab | 6.35+13.99 a | 5.29+12.46 ab | 4.49+9.99 abc | 6.01+8.77 a | 3.89+5.46 a | 0.0+0.00 a | **Microwave (15)min** | |
| 7.59+17.37 a | 8.95+14.44 ab | 7.88+12.72 ab | 7.56+11.08 abc | 7.33+10.06 abc | 6.04+8.46 bcd | 5.07+6.64 cd | 4.05+4.58 bc | 2.37+2.19 b | 0.0+0.00 a | **Microwave (5)min** | |
| 4.74+16.58 a | 4.19+15.62 ab | 3.85+14.44 ab | 6.53+11.66 abc | 6.24+10.93 ab | 5.94+9.85 ab | 4.78+7.7 bcd | 3.16+5.13 bc | 0.0+0.00 c | 0.0+0.00 a | **Control** | **Dry seeds** |
| 11.99+14.12 a | 11.99+11.98 ab | 10.89+10.51 ab | 9.79+9.06 bc | 7.3+5.24 bc | 4.32+3.1 de | 0.0+0.00 e | 0.0+0.00 d | 0.0+0.00 c | 0.0+0.00 a | **microwave (5)min** | |
| 8.55+10.85 a | 8.47+9.29 b | 8+7.4 2 b | 6.93+6.46 c | 5.4+3.91 c | 3.53+2.45 e | 0.0+0.00 e | 0.0+0.00 d | 0.0+0.00 c | 0.0+0.00 a | **microwave (10)min** | |
| 10.85+10.40 a | 10.55+9.43 b | 9.65+8.66 b | 8.47+7.60 c | 7.03+5.91 bc | 4.64+3.24 de | 0.0+0.00 e | 0.0+0.00 d | 0.0+0.00 c | 0.0+0.00 a | **microwave (15)min** | |
| 46.46+23.35 a | 9.57+8.95 b | 8.65+8.02 b | 7.76+7.10 c | 6.65+5.99 bc | 5.05+4.23 de | 2.24+1.03 e | 1.69+0.53 d | 0.0+0.00 c | 0.0+0.00 a | **microwave (20)min** | |

The different letters on the averages of the treatments within the comparison of the seed treatment or the plasma treatments or the interaction between them for each day indicate that there are significant differences ($P<0.05$) between the treatments. The results shown in Table (2) showed the effect of non-thermal microwaves on the stem length of the seeds soaked in water for 24 hours, where the average values were taken for ten seeds for each replicate, and it was shown that the seeds placed in water for 24 hours had a preference over the dry seeds by treating the seeds with There were statistically significant differences for most of the days during which the cultivation took place, as it was shown through the discussion the preference of pumpkin seeds soaked in water for 24 hours over dry pumpkin seeds. The reason for this is that pumpkin seeds have a very high percentage of inhibitors, and one of its properties is that when washed with water, these inhibitors are removed by 90%, which helps microwaves to activate the seeds and break the dormancy barrier. The interpretation of this agrees with the researchers' study [21].

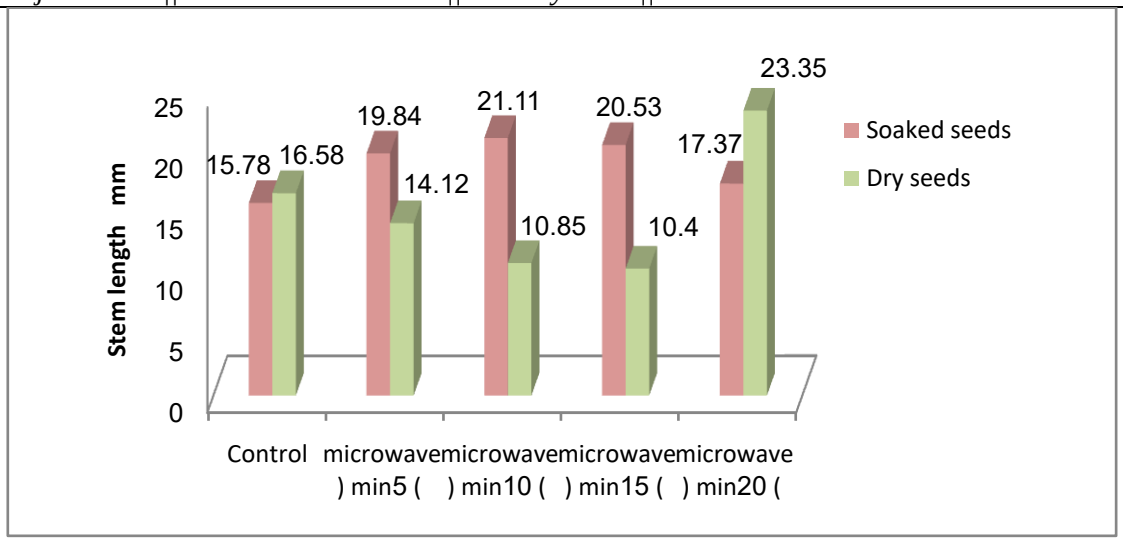


Figure 6:Effect of exposing pumpkin seeds to microwave technology at different times (0.5, 1, 3, 5) minutes on stem length (mm) for both seeds soaked for 24 hours with water and dry seeds after ten days of agriculture.

The results shown in Figure (5) showed the effect of non-thermal microwave on the stem length of the seeds soaked in water for a period of 24 hours. After taking the average values for ten seeds for each replicate, it was found that there is a positive effect of microwaves on the soaked seeds, as the exposure time exceeded (10)min it had the highest average germination for stem length (21.11mm), outperforming control seeds by 34%. The next exposure time came for the adult (15 min), who recorded an average growth of leg length (20.53 mm), outperforming the control by 30%. Exposure time (20min) from the exposure times ranked last, as it recorded (17.37mm), outperforming the control also by 10%. the microwave with the water content in the stems of the plant through the interaction of the microwave with the hydrogen molecules present in the water molecules, which helps it to increase, which generates the activation of germination with an increase in the length of the stem. This result agrees with [24]. They mentioned that the difference in water content helps toincrease the growth of stems in plants. While in the dry seeds, the effect of microwave is negative, which makes the seeds exposed to the microwave less germinated than the unexposed seeds (control).However, in our experience, the opposite of this was achieved in the exposure time (20) minutes exclusively, as shown in Figure (5), and this raises attention, and perhaps there will be a change in the shape of the stem or a mutation in the advanced stages of germination, and we will look for the reason for this in the upcoming studies.

Table (3): shows the effect of microwave exposure on pumpkin seeds soaked for 24 hours and dry seeds for different periods of time on the number of leaves for a period of ten days (mean + standard deviation).

| Tenth Day | Ninth Day | Eighth Day | Seventh Day | Sixth Day | Fifth Day | Fourth Day | Third Day | Second Day | First day | Exposure Times | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.84±1.56 A | 0.84±1.56 A | 1.0±1.12 a | 0.96±0.68 A | 0.89±0.52 a | 0.78±0.36 A | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Soaked seeds** | Seed treatment |
| 0.99±1.20 B | 1.0±0.84 B | 0.74±0.32 b | 0.61±0.20 B | 0.4±0.08 b | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Dry seeds** | |
| 0.82±1.60 A | 0.89±1.50 A | 1.02±0.90 a | 0.98±0.70 A | 0.62±0.20 A | 0.0±0.00 b | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Control** | Microwave treatment of seeds |
| 0.82±1.60 A | 0.94±1.40 Ab | 1.02±0.90 a | 0.73±0.30 A | 0.62±0.20 a | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (5)min** | |
| 0.98±1.30 A | 1.01±1.20 Ab | 0.89±0.50 a | 0.82±0.40 A | 0.62±0.20 a | 0.73±0.30 Ab | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (1)min** | |
| 0.98±1.30 A | 1.02±0.90 B | 0.98±0.70 a | 0.89±0.50 A | 0.62±0.20 a | 0.82±0.40 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (3)min** | |
| 1.02±1.10 A | 1.03±1.00 Ab | 0.94±0.60 a | 0.73±0.30 A | 0.62±0.20 a | 0.62±0.20 ab | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (5)min** | |
| **The interaction between seed treatment × microwave seed treatment** | | | | | | | | | | | |
| 1.03±1.2 abc | 1.03±1.2 abc | 0.97±0.60 bc | 0.97±0.60 ab | 0.63±0.20 bc | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Control** | Soaked seeds |
| 0.0±2.00 A | 0.0±2.00 A | 0.84±1.60 a | 0.84±0.40 ab | 0.63±0.20 bc | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (5)min** | |
| 0.63±1.80 Ab | 0.63±1.80 A | 1.05±1.00 ab | 1.03±0.80 ab | 1.03±0.80 ab | 0.97±0.60 A | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (10)min** | |
| 0.84±1.60 Abc | 0.84±1.60 Ab | 1.03±1.20 ab | 1.05±1 0 A | 1.05±1.00 a | 1.03±0.80 A | 0.0±0.00 A | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (15)min** | |
| 1.03±1.20 | 1.03±1.20 | 1.03±1.20 | 0.97±0.60 | 0.84±0.40 | 0.84±0.40 | 0.0±0.00 | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave** | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Abc | Abc | ab | ab | abc | Ab | a | | | | **(20)min** | |
| 0.0±2.00 A | 0.63±1.80 A | 1.03±1.20 ab | 1.03±0.80 ab | 0.63±0.20 bc | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Control** | Dry seeds |
| 1.03±1.2 0 abc | 1.03±0.80 Bcd | 0.63±0.20 c | 0.63±0.2.0 ab | 0.63±0.20 bc | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (5)min** | |
| 1.03±0.8 0 C | 0.97±0.60 Cd | 0.0±0.00 c | 0.0±0.00 B | 0.0±0.00 c | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (10)min** | |
| 1.05±1 0 Bc | 0.63±0.20 D | 0.63±0.20 c | 0.0±0.00 B | 0.0±0.00 c | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (15)min** | |
| 1.05±10 Bc | 1.03±0.80 Bcd | 0.0±0.00 c | 0.0±0.00 B | 0.0±0.00 c | 0.0±0.00 B | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | 0.0±0.00 a | **Microwave (20)min** | |

The different letters on the mean of the treatments within the comparison of the seed treatment or the microwave treatment or the interaction between them for each day indicate that there are significant differences ($P<0.05$) between the treatments. Where the results shown in Table (3) showed the effect of non-thermal microwave on the number of leaves of seeds soaked in water for 24 hours, where the average values were taken for ten seeds for each replicate, and the preference of seeds placed in water for 24 hours over dry seeds was shown by treating the seeds. There were no statistically significant differences between the soaked seeds and the dry seeds for the first four days because the results were zero and the differences started from the fifth day until the tenth day of agriculture, and the interpretation of this agrees with the study of researchers [25].

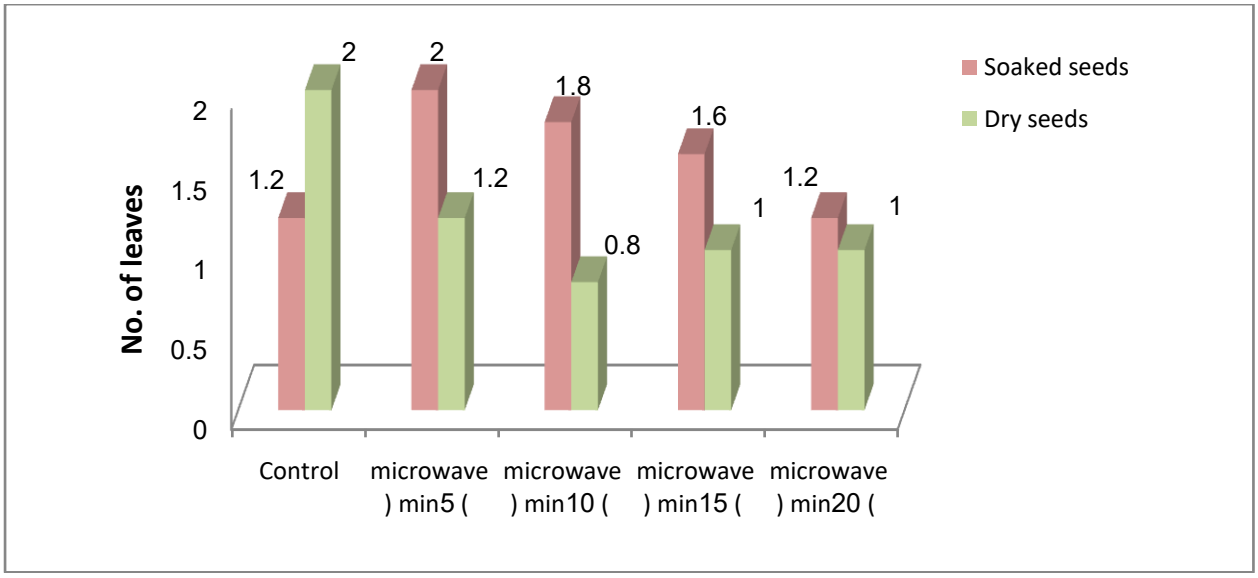


**Figure 7**:The effect of exposing pumpkin seeds to non-thermal microwave technology at different times (5,10,15,20) minutes on the number of leaves for each of the seeds soaked for 24 hours with water and dry seeds ten days after agriculture.

The results shown in Figure (6) of the effect of non-thermal microwave on the number of leaves of seeds soaked in water for 24 hours showed that there were no significant differences between the exposure times compared to the control group, where when using seeds soaked in water for 24 hours there was a positive effect of waves microbes on the soaked seeds, where it exceeded the exposure time of (5) min by registering the highest average number of leaves for ten seeds (2), surpassing the average number of leaves for ten seeds not exposed to microwaves (control) by 67%, while with a time of (10) min the average number of leaves was recorded When the seeds were exposed to microwaves (1.8), they were superior to the control by 58%. The exposure time (15) minutes comes after them, recording an average number of leaves for ten seeds (1.6), surpassing the control by 40%, as the exposure time (20) minutes is equal to the control group, recording the average number of leaves for ten seeds (1.2), and this means that the greater the effect of microwaves on Plant seeds for (20) minutes, its effect will be negative, while when the seeds are exposed to a shorter time than it works to stimulate the growth of the number of leaves, where the positive effect of the microwave was to increase the number of leaves in the germination process, which helps the plant to improve the process of photosynthesis, and this is consistent with what was proven by researchers [26] they all noticed that increasing the number of leaves helps to improve the process of photosynthesis in the plant.

## 5. Conclusions

In this study the pumpkin seeds was exposed to a non-thermal microwave at a distance of 5 cm from the samples for different times (5,10,15,20)min. It is found an achieved the lowest time to break the dormancy barrier for the seeds soaked with water was (5min) for root length, as it outperformed the control by 7.7%. The best result was achieved in the same capacity at the time (15min). Where the percentage of superiority over the control group was 8.9%. The results also showed that the pumpkin seeds that were washed with water or peroxide got rid of the inhibitors on their cover, which made them superior to the dry seeds. Also It was found that a long exposure times will destroy the seed cells, which made the microwave technology desirable in recent times because it is used with short times and good results at the level of seed activation.

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