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A RESEARCH ABOUT MICROWAVE EFFECTS ON THE WEED PLANTS

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ABSTRACT

In this study, the applicability of microwave weed control methods in destruction of weeds which causes significant losses in agricultural production was investigated. In research, charlock, wild oats and cress plants have been used. After they germinate, vitality rates and damage levels of the plants which exposed to microwave energy were determined. For this purpose, we developed a moving belt experimental test tunneling mechanism. Then, germinated weeds were passed through a speed control microwave tunnel with the 400 mm x 600 mm x 1200 mm dimensions, and volume of V = 0.288 cubic meter applying with the help of adjustable microwave energy densities; 9.72 kW/m^3, 7.29 kW/m^3, 4.86 kW/m^3 and moves with five different speeds of 0.01 m/s, 0.026 m/s, 0.050 m/s, 0.090 m/s, 0.15 m/s. The moving belt system was used to simulate the movement of the tractor in the field. According to the study results, depending on exposure duration, weed spices and microwave energy density; different death rates changing from 4 % to 100 % were determined.

Keywords: microwave, weed seeds, germination, inhibition.

INTRODUCTION

Chemicals used in weed control affect the physiological development of weeds and aim to minimize the economic loss or eradicate it completely. Weed control methods practiced by using chemicals are used in weed control in the non-agricultural areas as widely as in the agricultural areas. However, as the detriments of the chemicals usage is understood and the environmental awareness increases, a tendency towards using non-chemical weed control methods have been taken especially in the organic agricultural practices.

In the wake of the competition between weed and cultivar, depending on the weed species, a yield loss by 20-100% may occur.

Weeds also restrict effective machinery usage during the yield and the storage. One third of the curing process expenses in cultivars is composed of the weed control expenses. In Australia only in the year of 2006, yield loss and weed control expenses stemming from weeds reached four billion dollars in total (Daff, 2006). Developed and developing nations raise the attention towards the waste and residual levels of the drugs detrimental to the human and environmental health, and take some precautions (Tobi et al., 2009). Due to the detriments of the chemicals used in agricultural control on the human and animal health, bans on the usage of such chemicals in numerous countries created room for the studies for alternative control methods. To wit; in the conducted scientific studies, it was determined that only the ozone treatment method can distill the herbicides in the drinking water (Hua, 2006). In a study conducted by Ying (2000), it was determined that four days after the usage of trifluralin and oxyflourfenin from among the herbicides used in the vineyards, there was no residue; but that norflurazon and oxadiazon left residue on the vines and the soil and this causes a serious danger during consumption.

The basis of heating with microwave is to increase the movement speed of the molecules such as water by upping the frequency and the temperature in the material rises with the increase in the thusly-occurring molecular vibration and crush (Matexas & Meredith, 1993; Krasewski & Nelson, 1995). To harmonize with the polarity of the rapidly changing electric field, due to the friction of the rotating polar molecules with one another and with the other molecules in the vicinity, heat occurs and so the yield heats up (Mudget, 1986; Buffler, 1993).

Microwave as a weed control method has been tested with studies such as the agricultural soil disinfestation, restricting the germination of weed seeds with microwave and the eradication of the non-wholly germinated weed seeds by being left under the microwave energy. Hereof studies have been conducted since 1970s.

The physical disinfestation method carried out with high-frequency electromagnetic waves (1-1000 GHz) increases the temperature of pathogens and weed seeds, thus the occurring death of the plant after the plant body and its leaves wither in a short while (Davis, 1971; Nelson, 1996). In the study conducted by using a quantity of four 2.45±20GHz magnetrons, germinated plants were observed to have died due to the usage of microwave energy on these plants in differing durations (Wayland and Menges, 1975). In an experimental research conducted by Velazquez et al. (2005), studies to determine the effects of the microwave radiation on restricting the germination of unwanted seeds have been carried out.

Since the disinfestation of the soil with the microwave thermal process does not leave behind any residue (Olsen & Hammer, 1982; Nelson, 1985; Mavrogianopoulos, 2000) it becomes an alternative to the chemical weed control method. Thus it is expected that many studies are to be made in the future, as the microwave or the electromagnetic method is an environmentalist alternative method.

In this study, a microwave tunnel consisting from a quantity of four 1-kW magnetrons with the speed-controlled conveyor belt designed to be used in experiments was used. In research, after the germination of charlock, wild oats, and cress plants in the optimum temperature and moisture levels, results occurring from using the microwave energy on different powers and speeds have been examined. Determining the probability of using this method in weed control and even obtaining efficiency at some levels is extremely important in terms of the savings one can make from the agricultural drugs to be used in this aspect, and most importantly the gains to be had from the aspect of environmental pollution.

MATERIAL AND METHOD

Material

So that charlock and wild oats and other weed seeds gathered from natural environments would germinate in the right temperature and moisture, the pure water that is required for the damp and light-controlled IK-300 air-conditioning cabinet and dampening unit was obtained in the QM 00178 pure water device.

In research, to simulate the tractor movement in experiments, a movement belt was developed with a frequency range changing between 0.01 Hz to 1.00 Hz and with Power Flex 4M motor driven; it has a speed that takes 100 different values between 0.0099 ms^{-1} (0.03564 kmh^{-1}) and 0.156 ms^{-1} (0.5616 kmh^{-1}). The conveyor belt usable in different speeds is 4.5 m at length, 60 cm at bandwidth and is 70 cm at height (Figure 1).

Figure 1. Conveyor belt, electric motor and speed driver.

The microwave tunnel to create microwave energy is at a 125x60x40 cm size, was manufactured from galvanized steel at a thickness of 5 mm and 4 microwave generators with each being 1 kW were mounted onto it. The microwave output power of the magnetrons is 700 W (Figure 2, Figure 3 and Figure 4).

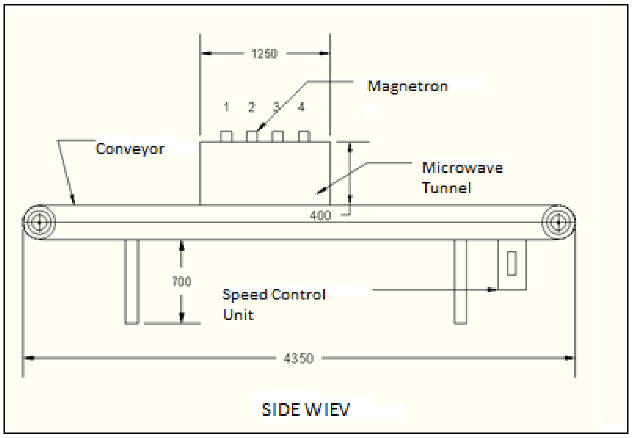

Figure 2. Side-view of conveyor belt and microwave tunnel.

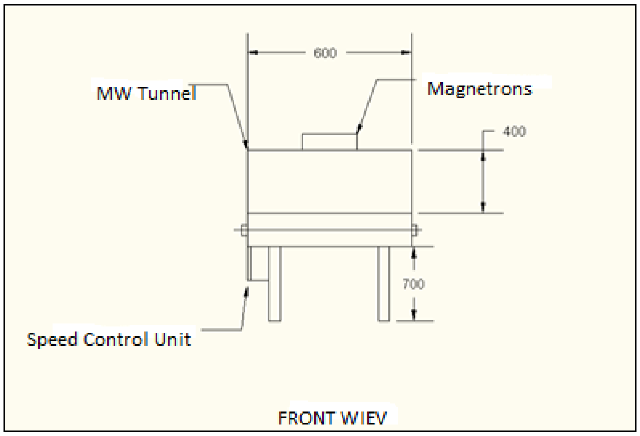

Figure 3. Front-view of conveyor belt and microwave tunnel.

Figure 4. Mounting conveyor belt and microwave tunnel.

Charlock and wild oats seeds naturally-grown in agricultural areas, and cress seeds obtained from the market were preferred to be used in experiments.

RMS digital multimeter that was obtained to be used in processes such as troubleshooting during the montage of the microwave generator to the tunnel, measuring the electronic circuit voltage and current used during studies and the robustness test of electronic elements is an EX400 model RMS digital multimeter with a voltage measurement accuracy of ± % 0.3 reading+ 2 digits and a current measurement accuracy of ± % 1.5 reading+ 6 digits.

Two pieces of BR15 model microwave detectors to be put into different spots were used during experiments for measuring the leakage that may come out from the tunnel while the microwave generators are working and determining whether or not this leakage exceeds the security limit defined by FDA (U.S. Food and Drug Administration) and EPA (U.S Environmental Protection Agency) to be as 5 mWcm^{-2} (Figure 5). The microwave detector has a frequency calibration of 2.450 MHz and a measuring range of 0-9.00 mWcm^{-2}. Measurement accuracy sensitivity; ± 1 dB and warning measurement value; 5 mWcm^{-2}.

Figure 5. Microwave radiometer.

The DT-615 model digital thermometer and moisture meter was used to measure the soil temperature and moisture of the germinated weed seeds before they are put into the microwave effect and during their exit from the microwave tunnel. Semi-conductor sensor measurement of the device; 0 ºC -40 ºC and thermocouple large temperature measurement range is between -20 ºC and 1000 ºC. Moisture measurement is 0.1% RH and 100% RH; its accuracy is ± 3.5 % RH. K-tip prop accuracy is ± 3.0 reading + 4 ºC.

Methods

Weed seeds used in the study were readied for the experiments by being germinated in the air-conditioning cabinet for varying durations as 5, 7, 10, 15 and 30 days based on the weed species. The speed-controlled conveyor belt was adjusted to five different speeds of 0.01 ms^{-1}, 0.026 ms^{-1}, 0.050 ms^{-1}, 0.090 ms^{-1}, 0.15 ms^{-1}. Different speeds are obtainable for varying frequencies in the speed driver used in conveyor belt.

Each one of the microwave generators used in the tunnels we developed and designed had a stable frequency of 2.45 GHz and had a 700 W microwave output potency.

The microwave tunnel that had 1 kW magnetrons with a quantity of four was operated on different power levels. As the no. 1, 2, 3 and 4 magnetrons were active, 4x700 Watt potency was read; as the no. 1, 3 and 4 magnetrons were active and no. 2 magnetron was passive, 3x700 Watt potency was read and as the no. 1 and 3 magnetrons were active while the no. 2 and 4 were passive, a potency of 2x700 Watt was read. 2800 Watt was defined as 2.45 GHz “high power level”, 2100 Watt as 2.45 GHz “medium power level” and 1400 Watt as 2.45 GHz “low power level”.

At the A energy level while all of the no. 1, 2, 3 and 4 magnetrons were active; 4x700 W, the total microwave output power was read as 2800 W, the volume as 0.288 m^3 and the microwave energy density as 9.72 kWm^{-3}.

At the B energy level while no. 1, 3 and 4 magnetrons were active and the no. 2 was passive; 3x700 W, the total microwave output power was read as 2100 W, the volume as 0.288 m^3 and the microwave energy density as 7.29 kWm^{-3}.

At the C energy level while no. 1 and 3 magnetrons were active and the no. 2 and 4 were passive; 2x700 W, the total microwave output power was read as 1400 W, the volume as 0.288 m^3 and the microwave energy density as 4.86 kWm^{-3}.

After the seeds required to be germinated had been planted in the pots filled with a soil-turf mixture, the pots were observed and recorded since the beginning of the germination by means of daily watering in the air-conditioning cabinet at a temperature of 23±3 ºC and moisture of 60±10 % after being covered with a turf-soil mixture at an approximate thickness of 1 cm.

On three repetitions, the germinated plants were left under the microwave energy effect at five different speeds of 0.010 ms^{-1}, 0.026 ms^{-1}, 0.050 ms^{-1}, 0.090 ms^{-1}, 0.15 ms^{-1} and on three different power levels of 2800 W, 2.45 GHz “high power level”, 2100 W, 2.45 GHz “medium power level” and 1400 W 2.45 GHz “low power level”.

Experimental examples to which microwave has been applied and germinated plants to which the microwave process has not been applied were observed again in the air-conditioning cabinet under the same conditions and their photos were taken to make comparisons. After the microwave application, active and quiescent plants were detected at the end of each experiment. Statistic package software was utilized in analyzing the obtained data.

FINDINGS AND DISCUSSIONS

Because the wild oat seeds germinated for seven days belong to the leafed weed group, cress seeds from the large leafed weed group were planted into sixty pots (100±10 seeds for each pot) to research whether or not the microwave effect causes a different impact on the large leafed weeds. A week after germination, seeds were tested in durations of 126 s, 49 s, 25 s, 14 s and 8.5 s and on power levels of 2800 W, 2100 W and 1400 W. After seven days from the beginning of germination, cress plants were detected to be of a height at approximately 6±2 cm (Figure 6).

Figure 6. Germinated cress seeds.

Pot soil temperature values of the plants before the microwave application, pot soil temperature values right after the application of microwave energy, conveyor belt speed values and speed driver frequency values were determined. Fifteen pots, microwave not applied, were preserved to be compared in the incubator conditions (23±3 ºC temperature and % 60±10 moisture). The total number of planted seeds is 60x100=6000 and the germinated seed number is approximately is 5500. Cress plants were observed and recorded before their exposure to microwave and right after the microwave application. After the application, growth of these plants was recorded daily by means of preservation in the air-conditioning cabinet under the germination conditions.

At the A and B power levels, the ratio of the weeds dying is relatively high at the speeds of V1 and V2 (126 and 49 seconds). However, at the A and B power levels, germinated cress seeds kept being wholly active at the speeds of V3, V4 and V5 (25, 14 and 8.5 seconds). After seven-days old cress seeds, at the A, B and C power levels, were exposed to microwave at the speeds of V1, V2, V3, V4 and V5, numerical values of the active and quiescent plants calculated.

Below, in the Figure 7 is given the state of the cress plants, to which microwave energy is applied, at the end of day five on the A power levels at five different speeds.

Figure 7. T-A-V1 Before microwave exposure and 5 days after MW exposure.

In research, awaited results were obtained from the weeds such as charlock, wild oats, cress to which microwave energy were applied on different power levels, in differing durations.

These results basically are the weeds becoming quiescent on different ratios based on the power level and the application duration (conveyor belt progress speed) applied to the weeds, which microwave is applied to, after a short while from germination. Death ratios, which occur on the A, B and C power levels and at the speeds of V1, V2, V3, V4 and V5, of the wild oats among the weeds are given in the Figure 8, Figure 9 and Figure 10.

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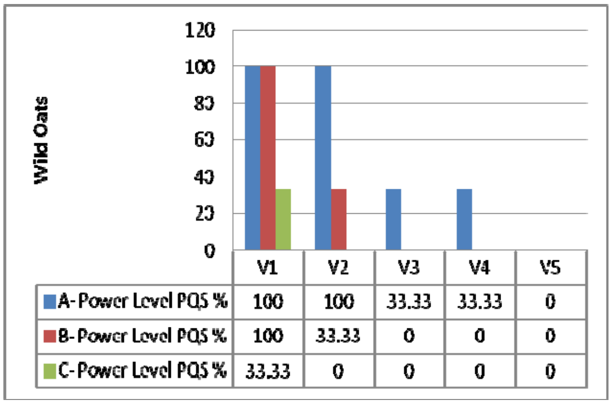

Figure 8. Motality rates occouring in wild oats at A,B,C power levels.

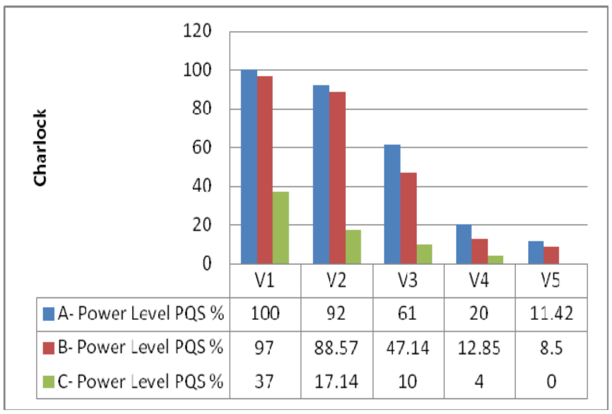

Figure 9. Motality rates occouring in charlock at A,B,C power levels.

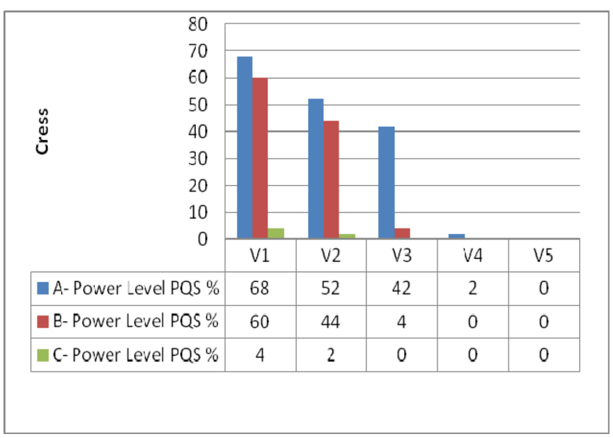

Figure 10. Motality rates occouring in cress at A,B,C power levels.

As can be seen in the Figure 8, all wild oat plants become quiescent in the wake of the microwave application on the power level A, at the speeds of V1 and V2. Again, all wild oat plants died at the speed of V1, on the power level B. On the B and C power levels, at the speeds of V3, V4 and V5, all of the plants persevered.

As can be seen in the Figure 9, 90% and more death ratios regarding charlock plants were obtained after the microwave application on the A and B power levels, at the speeds of V1 and V2.

However, contrary to the wild oats, changing death ratios between 4% and 47% were seen in the charlock plants on the A, B and C power levels, at the speeds of V3, V4 and V5.

As is seen in the Figure 10, death ratios circa 45-70% were recorded in the cress plant after the microwave application on the A and B power levels, at speeds of V1 and V2.

But it was observed that almost all of the plants persevered at the speeds of V1, V2, V3, V4 and V5 on power level C, and at the speeds of V4, V5 on power level B.

RESULTS

According to the results gathered from the research; high death ratios were obtained from charlock, wild oats and cress exposed to microwave on adequate power levels and durations. Partial death ratios took place in the microwave applications with lower power levels and durations. On the A and B power levels and at the speeds of V1, V2; almost all of the wild oats and cress from the weeds used in the study became quiescent, this only happened with more than half of cress plants.

Research tested the applicability of the microwave as an alternative weed control method. Obtained results show that this non-chemical weed control method requires further development.

National fiscal burden and environmental effects that the chemicals used in the weed control cause in Turkey are known, thus supporting the researches to improve the non-chemical weed control methods is of paramount importance.

Abbreviations and symbols

Power	*Microwave tunnel total output power*
Period	*Exposure period of seeds to microwave energy*
NPS	*Number of planted seeds (number)*
PGS	*Percentage of germinated seeds (%)*
ΔT	*Initial and final temperature difference (°C)*
PQS %	*Percentage of quiescent seeds*

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