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Possibilities of Killing Weeds by Microwave Power

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Abstract: Weeds are the main problems for organic and traditional cropping system. According to the researches, it was found that weeds decrease the yield by 21-61% especially in cotton and corn production. Herbicides use for controlling weeds destroys the environment and increases the cost. Recently microwave applications are considered for controlling weed plants due to the growing concerns about herbicide resistance and chemical residues in the environment. Recent studies proved that microwave can kill the weeds effectively.
In this study, the possibilities of using microwave energy to kill the weeds between the rows were investigated in corn and cotton production at laboratory conditions. Four weed varieties cocklebur (Xanthium strumarium), Johnson Grass (Sorghum halepense (L.)), Black Nightshade (Solanum nigrum), Bermuda Grass (Cynodon dactylon) were selected since they are the most common weeds found at corn and cotton production. In the experiment, weeds with three different development stages: weeds with four leaves, eight leaves and weeds at seeding stage were exposed to minimum 0.8 kW and maximum 5.6 kW microwave power with four different forward speeds were 0.05 –0.1 – 0.3 - 1 m s^{-1}.
According to the results; all four types of weeds were be able to be killed by microwave applications. The required microwave power to kill the weeds increased with increasing forward speed. It was found that forward speed of 1 m s^{-1} was not effective to kill the weeds with maximum power of 5.6 kW. All four weeds required more power for killing when they are at late growing stages. Generally, cocklebur and Black Nightshade required less power comparing Johnson Grass and Bermuda Grass. Bermuda Grass was the only weed which required maximum 5.6 kW microwave power level at all forward speeds at laboratory conditions.
Key words: Microwave power, weed management

INTRODUCTION

The most important targets in the agricultural production which has a great importance in the Turkish economy are reducing costs and increasing production. Especially in the agricultural production weed control has a direct impact in terms of the yield and quality. Weeds are the main problems for organic and traditional cropping system. According to the researches, it was found that weeds decrease the yield by 21-61% especially in cotton and corn production. Herbicides use for controlling weeds destroys the environment and increases the cost.

Recently microwave applications are considered for controlling weed plants due to the growing concerns about herbicide resistance and chemical residues in the environment. Recent studies proved that microwave can kill the weeds effectively. Unfortunately, microwave application is still quite expensive comparing traditional weed control systems.

Burnside et al. (1986) reported that viable weed seeds in the soil can be reduced by 95% after five years of consistent herbicide management; however, Kremer (1993) pointed out that in spite of achieving good weed control over several years, weed infestations will recur in succeeding years if intensive weed management is discontinued or interrupted. These efforts to deplete the soil seed bank are hindered by the growing list of herbicide resistant

weed biotypes (Heap, 1997).Interest in the effects of high frequency electromagnetic waves on biological materials dates back to the late 19th century (Ark and Parry, 1940) while the interest in the effect of high frequency waves on plant material began in the 1920's (Ark and Parry, 1940). Many of the earlier experiments on plant material focused on the effect of radio frequencies (RF) on seeds (Ark and Parry, 1940). In many cases, short exposure resulted in increased germination and vigor of the emerging seedlings (Tran 1979, Nelson and Stetson 1985); however long exposure usually resulted in seed death (Ark and Parry 1940; Bebawi, et al. 2007; Brodie, et al. 2009).

Davis et al. (1971, 1973) were among the first to study the lethal effect of microwave heating on seeds. They treated seeds, with and without any soil, in a microwave oven and showed that seed damage was mostly influenced by a combination of seed moisture content and the energy absorbed per seed.

Other findings suggested that both the specific mass and specific volume of the seeds were strongly related to a seed's susceptibility to damage by microwave fields (Davis, 1973).

Brodie et al. (2007b) studied the effect of microwave treatment on Marshmallow (Malva parviflora) seedlings, using a prototype microwave system based on a modified microwave oven.

The objectives of this study were to determine the possibilities of using microwave energy to kill the weeds between the rows and find out the limit power levels for killing the weeds which becomes a great problem in corn and cotton production.

MATERIAL and METHODS

The research was conducted at laboratory of Agricultural Machinery and Technologies Engineering Department, Faculty of Agriculture, Ege University in the years of 2015 and 2016. For killing the weeds 16 kW microwave oven was designed and manufactured which shown in Figure 1.

Figure1. Laboratory prototype of microwave oven

The specifications of the microwave oven were given in Table 1.

Table 1. The specifications of microwave oven

Microwave Power (kW)	Min: 2.4 Max: 16
Length (m)	Total 7.5
Speed (m sec^{-1})	Min: 0.001 Max: 1

The prototype can be controlled by a PLC and can be adjusted by control panel therefore different forward speeds and microwave powers can be applied to different weeds. By the help of this feature, field conditions were simulated at laboratory condition.

The effect of microwave power on the weeds were determined by observation. All weeds were examined by eye, according to their effected level.

Four different weed species were selected which assumed to be a problem especially for corn and cotton production in Ege region, Turkey. Selected weed species were Cocklebur (*Xanthium* Strumarium*), Johnson Grass (Sorghum halepense (L.)), **Black Nightshade** (Solanum nigrum), and Bermuda Grass (Cynodon dactylon)* which shown in Figure 2.

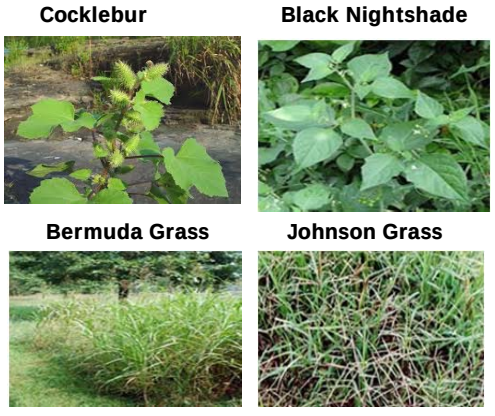

Figure 2. Weed species

To examine the microwave power effect on the weeds, all microwave power levels at different forward speeds were used to determine the level of power to kill the weeds. In the preliminary tests, 7 different power levels with 4 different forward speeds were used to kill the weeds at 3 different growing stages. For this purpose, 3 different weed stages selected. In first stage, the weeds had 4 leaves, in the second stage 6-8 leaves and the last stage was the seeding stage of the weed.

Weeds were exposed to minimum 0.8 kW and maximum 5.6 kW microwave power with 4 different forward speeds of 0.05 –0.1 – 0.3 - 1 m s^{-1} for each growing stage of the weeds to determine the effect of the microwave power on the growing stage of the weeds.

The weeds were observed for their conditions whether or not they are dead or survived after exposing to the microwave power.

RESULTS and DISCUSSION

According to the results; all four types of weeds were be able to be killed by microwave applications.

The required microwave power to kill the weeds increased with increasing forward speed. The weeds were not affected by microwave power at forward speed of 1 m s^{-1}.

Generally, cocklebur and Black Nightshade required much less power comparing Johnson Grass and Bermuda Grass. Bermuda Grass was the only weed which required maximum 5.6 kW microwave power level at different forward speeds at laboratory conditions.

The microwave power for killing the weeds at maximum speed of 0.3 m s^{-1} were measured as 2.4 kW, 3.2 kW, 4.8 kW and 5.6 kW for Cocklebur, Black Nightshade, Johnson Grass and Bermuda *Grass* respectively (Figure 3 & 4).

Figure 3. Cocklebur & Nightshade before and after microwave application

Figure 4. Johnson Grass & Bermuda Grass before and after microwave application

Growing stage was found effective on the required power level to kill the weeds. All four weeds required more power for killing when they are at late growing stages.

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