ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 08, pp.36870-36874, August, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

COLOUR AND WEIGHT CHANGES OF AUBERGINE, BEAN, CUCUMBER BY THE EFFECTS OF MICROWAVE ENERGY

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ARTICLE INFO

Article History:
Received 03rd May, 2016
Received in revised form
20th June, 2016
Accepted 05th July, 2016
Published online 31st August, 2016

Key words:
Aubergine,
Bean,
Cucumber,
Microwave,
Colour,
Weight.

ABSTRACT

In many agricultural productions, especially in the production in the open field, pests have negative effects. As they can be effective during the production process, they can cause economic losses after harvest even after the sale. In this study, it is aimed to reveal in what way the plants will be affected when microwave energy is applied to the plants of bean, cucumber and aubergine in greenhouses and in the applications where the usage of microwave energy has become widespread. For this purpose, first, the power of microwave energy that the plants are affected, the duration of exposure to this power and the distance of the system from the target have been detected by preparing a testing apparatus. During these studies, in what way the plants were damaged in terms of colour and weight have been followed so they damaged. In the applications, as the application time was getting increased and the application distance was getting decreased, malicious mortality rate and weight and colour values of the plants also increased. As the value of microwave power was getting increased, there were some increases at the exchange rate of all measured values. However, since there were some tears at certain points, especially in stem sections, the smoothness of the measured value were impaired and irregular data were obtained. Colour and weight changes of aubergine, bean, cucumber by the effects of microwave energy determined

Citation: IlkerHuseyin CELEN, Soner CELEN, Eray ONLER, Mehmet RecaiDURGUT, Erdal KILIC and Nurfer KAMA. 2016. "Colour and weight changes of aubergine, bean, cucumber by the effects of microwave energy", *International Journal of Current Research*, 8, (08), 36870-36874.

INTRODUCTION

Agricultural control is the protection of the plants from the adverse effects of diseases, pests and weeds within economic criteria and the improvement of the product and the quality. In agricultural control, the applications having the least negative effects on human and environmental health and detected by taking advantage of all the known methods must be used to achieve this goal. As it is known, agricultural control contains very different methods. The control using pesticides that is known as the most effective and widely known method is one of them. Human health and environment have gained great importance at modern world, the risks to form resistance in harmful organisms as a result of irrational and uncontrolled use of pesticides and their adverse effects on human health and environment via the remnants should not certainly be ignored.

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Recently, the researchers have been conducting various studies in order to eliminate the chemical usage. For this purpose, various thermal trials have been made. Besides this, especially in stores, it was started to be developed various methods by using radio frequency and microwave energy (Kilic *et al*., 2016). Some studies have been conducted especially on weeds seen in the fields(Velazquez-Marti *et al*., 2008)and the pesticides giving harm to the plants (Brodie, 2011; Rahi and Rich, 2011)It has not been encountered any application on cultivated plants. In the light of the data obtained, although it was tried to be made the designs of some systems, it was not seen any study transferred to the application. One of the reasons why there is no study of this matter is thought to be the negative effect of microwave energy to human health. Microwave radiation is included in the non-ionized group. They do not change the structure of the cells of items and living beings, and they do not give harm as radioactively. According to the studies conducted by the World Health Organizationon the contrary, to the common belief arouse in the public, no direct relationship has been revealed between

magnetic field created by RF transmitters and cancer. As a result of the trials conducted on animals, the World Health Organization has issued a report indicating that being in the magnetic field created by RF transmitters does not increase the risk of cancer (WHO, 2006).These results have played an important role in introducing microwave to food industry. In pesticide control, the usage of microwave energy especially after the exit ensures less energy consumption compared to the other thermal methods (Sartorato *et al*., 2013). Besides, it is encountered with some limitations such as, fire risk in flaming struggle, and heavy loads in hot water methods. Microwave and radio frequency heating have many potential applications in the agricultural and forestry industries (Emieenor *et al*., 2012).

The period in which growth of plants, the largest harmful Tetranychusurticae Koch (Acarina: Tetranychidae) red spiders (Rahi and Rich, 2011; Polat and Kasap, 2011). In order to do this, instead of pesticides used in the microwave when it is necessary to know how plants are affected. In this study, it was aimed to reveal in what way (colour and weight change) the plants such as aubergine (*Solanummelongena L.*), cucumber (*Cucumissativus*) and bean (*Phaseolus vulgaris L.*) will be affected when microwave energy is applied.In the light of the data obtained, the appropriate microwave power, application time and distance parameters to be applied to the plants have been revealed.

MATERIALS AND METHODS

As materials to be used in the research, beans (*Phaseolus vulgaris L.*), cucumber (*Cucumissativus*) and aubergine (*Solanummelongena L.*) were chosen as application plants. The plants grown in big flowerpots were exposed to microwave energy in measurement system prepared in the laboratory. Colour and weight changes in plants were examined. The plant seeds that were needed to be used in the tests to be conducted in the project were planted in big flowerpots in the area formed in laboratory more than the number it is needed and the production was continued during the trials for unexpected needs. Testing apparatus is composed of magnetron system spreading microwave energy, electric component and the frame carrying this system and ensuring the ability to adjust the distance to the surface area (fig1). The system can be adjusted according to a maximum of 700W and a minimum of 90W and the medium of 350W power values. Besides, the distance of the magnetron nozzle from the target surface can be zoomed and removed according to the desired level. In order that magnetron can be operated by the system voltage of magnetron of 220V AC, it is formed by onepieces of transformer, noise filter to reduce the electrical noise coming from the system, two adjustment buttons to allow making time and power settings, power electronics circuit consisting of a lamp indicating that the system is running. Magnetron creates microwave having the frequency of 2450 MHz taken from the electric network. In the prepared test unit, preliminary tests were conducted at the plant to detect their threshold of damage. Inthese preliminary trials, since it was observed that during 3-5 leaf period, the plants were affected from the microwave, the studies were conducted on these plants while being in 3-5 leaf period.

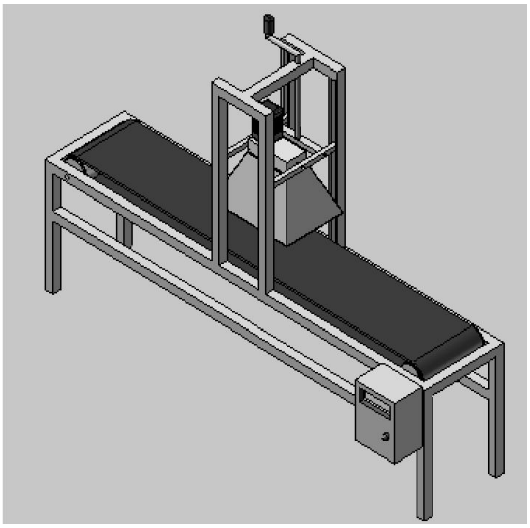


Figure 1. Microwave test unit

The measurements were made after bean, aubergine and cucumber plants had been removed from their flowerpots when they were in 5-leaf period, and the soil particles on it had been removed. For this purpose, the borders to be used in the trials in terms of different height, application time and the energy amount given were detected. As a result of these trials, the distance between magnetron nozzle and the target surface was detected to be 15cm, 25cm and35cm and the application time were detected to be 5s, 10s, 15s and 20s. As microwave powers from which the plants were affected during this period and at this distance, the change rates to a maximum of 700W, a minimum of 90W and a middle power of 350W to be used in the trials were detected. By using these values detected, all trials were conducted in three replicates in testing unit. During the measurements, the weight and colour values of the plants (*L,a,b*) were measured separately before and after being exposed to microwave energy. For the weight measures of the plants and pesticides, precision scale branded RADWAG AS 220 / C / 2 (RADWAG, Poland) were used. In colour measures of plant materials handled during the trials, HP200 model of (Sinodevices, China) portable colour measurement device was used.

The values measured were calculated in terms of *L, a, b. L, a, b*ex presses the well balanced structure of colour space and that a kind of colour cannot be green or red or blue or yellow at the same time. Simple values can be used to describe the adjectives of red/green and yellow/blue. In CIE *L*a*b*; L**indicates the value of brightness, *a**indicates the value of red/green and *b**indicates the value of yellow/blue (Kose and Sahinbaskan, 2008). Measurement values were expressed as the relationship between the value before being exposed to microwave and after being exposed to it to be %. The results were evaluated by randomized blocks experimental design methods in statistical terms.

RESULTS

In the measurement conducted, each plant was discussed separately, and the results were evaluated.

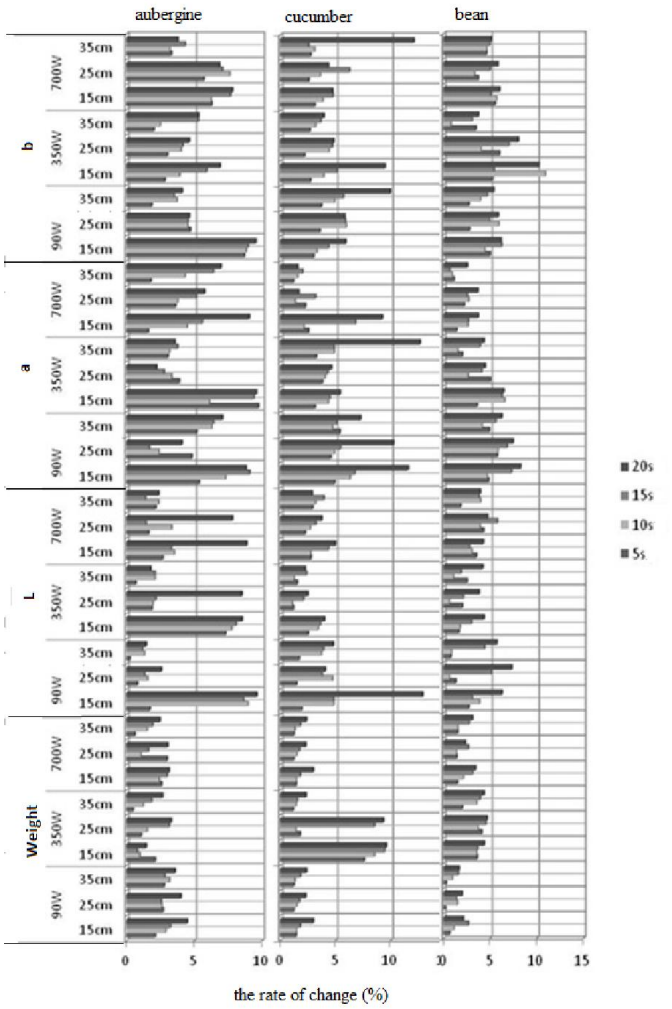
Due to being used of a different plant in each application, any proper increase cannot be seen in the rate of change. Although these plants were not in the same period, small differences in their physical structure were effective on their results. When the plant of aubergine (*Solanummelongena* L.) was exposed to microwave energy, the weight changes were detected while the power of microwave energy was getting increased. (fig 2). However, this change could not rise above 5 %. Microwave energy applied at different powers, different times and from different distances didn't show a smooth change. However, as the application time is getting increased, weight loss in plants was always increased. When application conditions were examined separately, very big changes could not be seen as the power was getting increased. While in the application conducted at the value of 90 W from the distance of 15 cm and for 5 sec. was 2.11 %, it was 2.09 % and 2.59 % at the power of 350 W and 700 W. However, with the change in time, its effects on the plants were changed. These values were measured respectively as 4.87 %, 4.5 % and 4 % in the application conducted for 20 sec. The differences between the effects of power and distance factors on the weight were seen to be slight. It was revealed that the effects of different times on the weight changes of microwave were important at the %95 confidence interval When LSD test was applied, it was found to be LSD: 5.158. For time factor, F values were calculated as 19.063^{a}, 11.185^{b} and 3.333^{c} for the values of 20, 15 and 10 s.

In the plant of aubergine, when the change in *L* value (brightness) in the power of 700 W was examined, it was observed that when the distance from the plant is getting increased, the change in *L* value decreased. Especially the applications made from the distance of 15 cm caused high change at different times. In the application made from the distance of 15 cm at the power application of 90W, the change respectively (5, 10, 15 and 20 s) was detected to be 1.72 %, 8,9 %, 8,6 % and 9.59 %. In general, the changes didn't show a proper increase. The plant of aubergine, the change of *L* value was at most 9.59 %. When Power-Distance-Time-Recurrences were examined separately and looked at their changes, the effects of differences among the factors on *L* value were seen negligible.

In aubergine plant, the value of *a* was especially effective when it was applied to the value of 350 W and from the distance of 15 cm and it showed a change at *a* maximum of 9.71 %. Generally, in all applications when the execution time is getting increased, a value change has varied. When Power-Distance-Time-Recurrences were examined separately and; the effects of differences among the factors on a value were seen negligible. In the plant of aubergine, the change of b value at the power of 700 W decreased as the distance is getting increased. The change of *b* value showed an improper change depending on the time. The biggest change (9.52 %) was seen in the application conducted at 90W of power value for 20 sec. time and from the distance of 15 cm. After this value, an explosion occurred especially in stems depending on the heat, and the plant lost its life feature. So, power value change showed very different exchange value changes. When Power-Distance-Time-Recurrence were examined separately and looked to their interaction with each other, the differences of the effects on b value were seen to be negligible. In the plant of cucumber, *(Cucumissativus)* while the time is increasing, the change showed an increase in all applications. In the application of the power of 350Wand from the distance of 15cm and with the application conducted for 20 sec., it was 9.57%. Generally, after this power value, explosions were seen in the stems. When factors were examined separately and looked to their interaction with each other, the differences between the differences between the effects of weight value of the factors were seen to be negligible (fig2). In the plant of cucumber, in long term applications from close distance, the change in L value was high (12.8%). When microwave power is increased (700W), it was encountered a change at the rate of 2.91% from the distance of 35m. When Power-Distance-Time-Recurrence were examined separately and looked to their interaction with each other, the differences of the effects on *L* value were seen to be negligible. In long term applicatios from close distance, the change in a value was the highest; in the applications at the level of 350W and from the distance of 35cm, when the application time lasted for 20 sec., the change rate was calculated to be 12.6%. When the power was increased (700W), in the application conducted for 15 sec., it was encountered with a change from the distance of 15cm and at the rate of 5.4%.

When Power-Distance-Time-Recurrence were examined separately and looked to their interaction with each other, the differences of the effects on b value were seen to be negligible. In the applications at the level of 700W and from the distance of 35cm and for 20 sec., a change at the rate of 12.08% was calculated in the plant of cucumber b. In the application at the value of 350W for 5 sec. from the distance of 35cm, this value has become 3.7%. a value of the plant of cucumber exposed to 90W power from the distance of 25cm and for 10 sec.has shown a change at the rate of 5.9%. When the factors were examined separately and in the interaction with each other, the differences of the effects on b value of all the factors were seen to be negligible. In the plant of bean, (*Phaseolus vulgaris* L.) in all applications conducted at the value of 350W, the biggest change in height was observed and when the values were increased, some explosions were seen in the plant stem. In the application of the value of 350W for 20 sec. from the distance of 25cm, 4.65% weight change rate was detected. As the time is getting increased, the rate of change also increased. When the power-distance-time were examined separately and looked to their interaction with each other, the differences between the effects on the weight value were seen to be negligible. Besides, the difference between the recurrences was found to be significant at the %95 confidence interval. When LSD test was applied, LSD was found to be 1.891. Among the recurrences, F values were calculated respectively as 1.779^{a}, 1.648^{a} and 1.000^{b} (Fig.2).

Figure 2. Microwave effect on cucumber plants eggplants, beans, (L, a, b, weight change). In the plant of bean, the highest L value (7.3%) change was seen in the application of 90W for 20 sec. and from the distance of 25cm. At the power rate of 700W, when the time was getting increased (5, 10 and 15 sec.), the change rate also showed an increase (4.26, 3.95 and5.76%).When the time is getting increased, the change rate also showed increase.



When Power-Distance-Time were examined separately and looked to their interaction with each other, the differences of the effects on L value were seen to be negligible. Besides this, the differences between the recurrences were found to be significant at the 95 % confidence interval. When LSD test was applied, LSD was found to be 2.198. F values between the recurrences were calculated respectively to be 5.779a, 5.648a and1.000 b.

In the plant of bean, in the application conducted at the power value of 90W, as the time is getting increased, a value change rate also increased. The highest change rate at the level of 8.23% at a value when it was exposed to microwave from the distance of 15cm for 20 sec., the highest 8.23% change rate was calculated. The plants to which it was applied microwave at the power value of 350W for the time of 10 sec. From the distance of 15cm showed a value change at the rate of 6.52%. At the power rate of 700W, some explosions were seen in the stems. When Power-Distance-Time were examined separately and looked to their interaction with each other, the differences of the effects on *b* value were seen to be negligible. Besides this, the differences between the recurrences were found to be significant at the 95 %confidence interval. When LSD test was applied, LSD was found to be 2.487. F values between the recurrences were calculated respectively to be 7.654^{a}, 6.464^{a} and 1.000^{b}. In the plant of bean, the highest *b* value change showed the highest change during the power applications at the rate of 350W.

At the power rate of 700W, when the time was getting increased (5, 10 and 15 sec.), the change rate also showed an increase (4.26, 3.95 and 5.76%). When the time is getting increased, the change rate also showed increase. When microwave energy having the power of 350W was applied from the distance of 15cm for 20 sec., *b* value was observed to have 10.9% of change. At the power rate of 700W, some explosions were seen in the stems. When Power-Distance-Time were examined separately and looked to their interaction with each other, the differences of the effects on a value were seen to be negligible. Besides this, the differences between the recurrences were found to be significant at the 95 % confidence interval. When LSD test was applied, LSD was found to be 0.616. Between the recurrences of 2^{nd}, 1^{st} and 3^{rd}, F values between the recurrences were calculated respectively to be 1.656^{a}, 1.633^{a} and 1.000^{b}.

DISCUSSION

In the plant of aubergine, during the applications conducted from the distance of 15 cm, the highest change rate was calculated respectively to be (Weight, *L, a, b*) 4.47%, 9.59%, 9.71% and9.52%. In all power values, the plant of aubergine exposed to microwave for the time of 20 sec. gave the highest change rates. When power value was used at the value of 700W, explosions were observed in the stems. In the plant of cucumber, the highest change rate (Weight *L, a, b*) was calculated to be 9.57 %, 12.8 %, 12.62 % and 12.08 % for 20 sec. during the application. In the plant of bean, while it was beginning to change at the power change of 90W for 20sec. from the distance of 15cm (8.23%), 7.3% of change was seen in the value of *L* when it was withdrawn to the distance of 25cm. When the power value was increased at the power of 350W, the change in *b* value during the application conducted for the time of 10 sec. and from the distance of 15cm was observed to be 10.9% while 4.65%ofthe weight change at the highest was observed from the distance of 25cm after 20 sec. In the applications, as the application time was getting increased, and the application distance was getting decreased, the change rate showed increase. As the microwave power value was getting increased, the rate of change was seen to rise. However at certain points, irregular data was taken due to the fact that regularity of the measured values was damaged since there were some tears especially in the stem section. For this reason a smaller power value was preferred. The results of these studies will be led to use microwave energy in agriculture and especially the design of the appropriate systems.

Conclusion

During these studies, in what way the plants were damaged in terms of colour and weight have been followed so they damaged. In the applications, as the application time was getting increased and the application distance was getting decreased, malicious mortality rate and weight and colour values of the plants also increased. As the value of microwave power was getting increased, there were some increases at the exchange rate of all measured values. However, since there were some tears at certain points, especially in stem sections, the smoothness of the measured value were impaired and irregular data were obtained.

Colour and weight changes of aubergine, bean, cucumber by the effects of microwave energy determined

Acknowledgements

This study has been conducted within the scope of SANTEZ, the Ministry of Science, Industry and Technology (01027-STZ-2011-2), by TARAL, Agricultural Machinery and Equipment Industry Co. Ltd. And Namık Kemal University. Thanks for their contributions.

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