Physical control of the Lesser Grain Borer *Rhyzopertha dominica* (Coleoptera: Bostrychidae) using various microwaves levels

Azher M. Ali[1]*

[1]Department of Plant Protection, College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq
***Corresponding author e-mail:** azhaer79122@gmail.com

Received:
Apr. 19, 2022
Accepted:
May 18, 2022
Published:
June 25, 2022

Abstract

This study was conducted in the year 2022 at the Department of Plant Protection, College of Agricultural Engineering Sciences, to evaluate the effect of microwave rays on various stages of the R. *dominica*. Microwaves of 220, 420 and 620 Watts at 30, 60 and 90 seconds effects on eggs, 4th instar larva, Pupas and adults were evaluated. The highest egg mortality was at 620 Watts for 60 seconds. Exposure to 620 Watts for 30 seconds increased the hatching period from 7.0 days for the control to 10 days 4th. Instar mortality was 100% at 620 Watt for 90 seconds. Pupae and adults 100 % mortality achieved at exposure to 620 Watts for 60 and 90 seconds, respectively. Generally, various stages of the R. *dominica* mortality increase by increasing the wattage and exposure time.

Keywords: Lesser Grain Borer, Physical control, microwaves.

Introduction

Microwaves are non-ionizing radiations, and their wavelengths are between the radio waves and the infra-red waves. It is considered safe for humans as it does not affect the properties and the nutritional values of treated materials [1] by using microwave rays in insect control is useful in agricultural quarantine treatments because it is fast, safe, close to the cost of chemical fumigation, and does not affect the treated food materials. It has been showed that the microwave and infra-red rays were more efficient than ultra-violet rays in killing all the stages of the red flour beetle *Tribolium castaneum* and the Khapra beetle *Trogoderma granarium* [2]. Studying the sensitivity of some insects' life stages, [3] noticed that eggs and early larval stages of the Lesser *R. dominica* are more sensitive to microwave rays [4]. Furthermore, the microwave ray was applied on an industrial level to estimate the mortality of larval and adult stages of three store insects, Maize weevil *Sitophilus zeamais*, red flour beetle *Tribolium castaneum* and the Indian Meal Moth *Plodia interpunetella*, and it was 100% at 600 watts for 28 seconds exposure. Another study [5] was examined the effect of microwave rays in controlling some stored cereal insects, including *R.dominica*, where adults' mortality was 83.3% at 800 watts, and 600 watts exposure for 45 seconds was enough to reach 100% mortality. As well as, it was investigated [6] the effect of the microwave ray on the *R. dominica* life stages in wheat that showed 100% mortality at 200, 400 700 watts for 90 seconds exposure for each life stage. Moreover, a research group [7] studied the effect of microwave rays on various life stages of the

honeybee comb moth, the Greater Wax moth *Galleria mellonella,* and found that mortality increases by the increase of energy and time to reach 100% at 600 watts for 30 seconds for all the life stages. When studying various microwave rays' energy levels on Angoumous Grain Mouth, *Sitotroga cerealella* [8] found that 90 seconds of exposure to 600 watts was enough to reach 100% mortality of all life stages. Thus, the aim of this study is evaluation of the influence of microwave rays on several stages of the *R. dominica* insect.

Materials and Methods

The experiment was conducted in 2022 at the laboratories of the plant protection department, College of Agriculture Engineering Sciences, University of Baghdad, using the German-made 1200 watts microwave of the brand Silver Crist. The energy levels**;** 220, 420, and 620 Watts for the durations of 30, 60 and 90 seconds for each level were applied to control various life stages of R. *dominica* (Eggs, fourth. Instar larvae, pupae and adults) reared on wheat (Abu Ghraib variety) in addition to a control treatment with no microwave ray applied. Each energy level was tested for each life stage and exposure time with three replicates for each treatment.

Eggs Exposure

9 cm diameter glass Petri dishes were used with 15 eggs at 24 hours of age. Eggs were exposed to 220, 420 and 620 watts of microwave rays for 30, 60 and 90 seconds for each experimental unit. The control treatment was not exposed to any rays. After treatment, each dish was sealed using a rubber band to prevent emerging larvae from escaping. Dishes were incubated at 30 ±2˚C and R.H. of 75 ±5% Egg Incubation period and mortality were recorded daily.

Larvae Exposure

9 cm diameter glass Petri dishes used with 15 larvae Fourth instar. Larvae were exposed to 220, 420 and 620 watts microwave rays for 30, 60 and 90 seconds for each experimental unit. The control treatment was not exposed to any rays. 15 gm of wheat was added to each dish to feed the larvae and emerging adults. After treatment, each dish was sealed using a rubber band to prevent larvae from escaping. Dishes were incubated at 30 ±2˚C and R.H. 75 ± 5%. Larval stage period and mortality were recorded daily.

Pupae Exposure

9 cm diameter glass Petri dishes were used with 15 twenty-four hours age pupae. Pupae were exposed to 220, 420 and 620 watts microwave rays for 30, 60 and 90 seconds for each experimental unit. The control treatment was not exposed to any rays. After treatment, each dish was sealed using a rubber band to prevent insects

from escaping. Dishes were incubated at 30 ±2˚C and R.H. 75 ± 5%. Larval and pupal stage periods, adults emerging percentage and adults' deformation percentage were recorded daily.

Adult Exposure

9 cm diameter glass Petri dishes were used with ten twenty-four hours age adults. Adults were exposed to 220, 420 and 620 watts of microwave rays for 30, 60 and 90 seconds for each experimental unit. The control treatment was not exposed to any rays. After treatment, each dish was sealed using a rubber band to prevent insects from escaping. 15 gm of wheat was added to each dish to feed the insects. Dishes were incubated at 30 ±2˚C and R.H. 75 ± 5%. Mortality percentage was recorded daily.

Statistical analysis

Genstat 2016 software was used to Analise the complete random design experiment.

Results and Discussion

Eggs Exposure

Table 1 shows the increasing mortality of eggs with the increase in energy levels and exposure periods, and the statistical significance was observed. The least egg mortality (2%) was recorded at 220 watts for 30 seconds of exposure. It was 100% at 620 watts for 30 seconds of exposure. The same table shows that the incubation period for eggs exposed to 220 and 620 watts for 30 seconds increased from 7.1 to 10.0 days, respectively, whereas the control treatment was only 7.0 days. [9] mentioned that the egg stage is more sensitive to microwaves, and showed that the cowpea weevil *Callosobruchus maculatus* eggs hatching was affected by the energy levels and exposure periods. Also, [10] found that the hatching percentage of the S. *granaries* decreased by increasing the microwave energy level due to its effect on cell division. It was studied [2] the effect of Microwaves energy levels on the T. *granarium* and T. *castaneum* eggs at 250, 350 and 500 watts and found that mortality was 9.9, 32.9, 34.3, 40.4, 49.6 and 76.8 % respectively. It was found [6] that egg mortality of the Lesser Grain Borer *Rhyzopertha dominica* increases with the increase of energy levels and exposure time to the microwaves, where he found that the highest mortality was achieved at 700 watts for 60 and 90 second exposure. The exposure to 600 watts for 90 seconds was enough to achieve 100% mortality of the Angoumous grain mouth, *Sitotroga cerealella* eggs [8].

Table (1): The effect of microwaves energy levels on the *R.dominica* eggs at 24 hours age.

Microwave energy level (Watts)	Exposure time (Seconds)	Mortality (%)	Incubation period (Days)
220	30	2.0	7.1
	60	32.0	7.8
	90	64.0	8.5
L.S.D (0.05)		3.5	0.8
420	30	54.1	8.4
	60	74.3	10.4
	90	86.2	12.0
L.S.D (0.05)		5.9	0.95
620	30	89.3	10.0
	60	100.0	-
	90	100.0	-
L.S.D (0.05)		9.3	0.91
Control		1.8	7.0

Larvae Exposure

Table 2 shows the effect of microwave energy levels on the fourth instar larvae R.dominica at 24 hours of age and development. Statistical analysis showed significant variances among treatments of energy levels, exposure times, mortality and adult emergence treated with microwaves. The highest Mortality was 21.0% at 220 watts for 30 seconds. Mortality increased with the increase of energy to reach 100% at 620 watts. Larval stages increased from 6.0 days in the control treatment to 7.8 days at 220 watts for 30 seconds of exposure. The most prolonged period was 10.4 days at 420 watts for 90 seconds. The treated larvae at 260 watts for 30 seconds resulted in 80.1 % adults, while it was 55% with the larvae treated at 420 watts for 60 seconds. The control treatment resulted in 100% emergence. The fourth instar stage period increased from 6.0 days for the control treatment to become 7.8 days at 220 watts for 30 seconds and 10.4 days at 420 watts for 90 seconds, respectively. Treated larvae at 220 watts for 90 seconds resulted in 45.5% adults and 55.1 at 420 watts for 60 seconds, respectively, compared to the control that resulted in 100% emergence. Additionally, it was found [11] that the Azuki Bean Weevil (*Callosobruchus chinensis*) and the R.*dominica* larvae exposed to microwaves mortality increased by the increase in exposure time and energy revealed that T. *granarium* and *T. castaneum* larvae were 77.3% and 41.4 %, respectively, at 500 watts for 30 seconds of exposure [2; 4] that showed R. *dominica* larvae mortality become 100% at 700 watts for 90 seconds, and

it was the same result achieved previously [6] when treated *Sitotroga cerealella* larvae with the same energy and time.

Table (2): The effect of microwaves energy levels on the 4th instar larvae of *R.dominica* and their development

Microwave energy level (Watts)	Exposure time (Seconds)	4th. Instar Mortality (%)	Incubation period (Days)	Emergence of Pupae (%)	Pupal stage period (Days)	Emergence of Adults (%)
220	30	21.0	7.8	80.1	8.1	80.1
	60	32.1	8.3	71.2	8.4	71.2
	90	55.3	8.5	45.5	9.2	45.5
L.S.D (0.05)		6.6	0.8	5.0	1.2	6.3
420	30	34.1	8.1	68.0	10.6	68.0
	60	47.2	8.8	55.1	11.4	55.1
	90	78.1	10.4	-	-	-
L.S.D (0.05)		7.8	0.8	5.2	0.8	5.6
620	30	74.0	-	-	-	-
	60	93.0	-	-	-	-
	90	100.0	-	-	-	-
L.S.D (0.05)		9.8				
Control	0.0		6.0	100.0	7.6	100.0

Pupae Exposure

Table 3 shows the effect of the microwave ray on the pupae of R. *dominica*, whereas the highest mortality was 100% at the exposure to 620 watts for 60 seconds compared to 0% for the control. Statistical analysis showed significant variances among treatments of energy levels, exposure times and pupal mortality. The longest pupal stage was 6.6 days at 220 watts for 30 seconds, 9.7 days at 420 watts at 60 seconds and 6.3 days for the control treatments. [12] says that treating the T. *castaneum* pupae with 30 watts at 8.5 GHz resulted in 100% mortality at 60˚C. [6] found that the highest pupal mortality of the R. *dominica* was 100% at 700 watts for 90 seconds exposure and it was found [2] at 600 watts for 90 seconds of exposing *S.cerealella* pupae.

Table (3): The effect of microwaves energy levels on the pupae of *R. dominica*

Micro-wave energy level (Watts)	Exposure time (Seconds)	Pupal Mortality (%)	Pupal stage period (Days)	Emergence of Adults (%)
220	30	37.1	6.6	64.0
	60	44.5	7.0	55.0
	90	67.1	7.6	33.1
L.S.D (0.05)		4.9	0.8	4.8
420	30	41.1	7.8	58.8
	60	82.2	9.4	18.8
	90	92.0	-	-
L.S.D (0.05)		8.6	0.7	5.1
620	30	90.4	-	-
	60	100.0	-	-
	90	100.0	-	-
L.S.D (0.05)		4.7		
Control		0.0	6.3	100.0

Adult Exposure

R.dominica adults' mortality, as shown in table 4, increased with the increase of wave energy and exposure time. Statistical analysis showed significant variances between factors of the treatment. The lowest adults mortality was 24.0 at 220 watts for 30 seconds of exposure and the highest, 100%, was at 620 watts for 90 seconds of exposure. [2] studied three energy levels (250, 350 and 500 watts) effect on *Tribolium castaneum* and *Trogoderma granarium* adults, and it was 47.0 and 59.2 %, respectively. [6] Studied the effect of microwaves energy levels on the R. *dominica* adults at 200, 400 and 700 watts for 30, 60 and 90 seconds exposure and the mortality was 40.6, 83.8 and 100% respectively at 90 seconds exposure of the above energy levels. When [7] studied the effect of microwave rays on the honeybee comb moth, the Greater Wax Moth, *Galleria mellonella,* found that 600 watts of exposure for 30 seconds resulted in 100% mortality [8] found that exposing *Sitotroga cerealella* adults to 200 watts for 30 seconds was 16.7%. It reached 100% at 400 watts for 90 seconds of exposure.

Table (4): The effect of microwaves energy levels on the adults of R. *dominica* at 24 hours age

Microwave energy level (Watts)	Exposure time (Seconds)	Mortality (%)
220	30	24.0
	60	37.0
	90	41.0
L.S.D (0.05)		**3.4**
420	30	44.0
	60	68.1
	90	84.1
L.S.D (0.05)		**4.7**
620	30	77.1
	60	91.2
	90	100.0
L.S.D (0.05)		**6.7**
Control		1.2

References

1) Wang, S, and J Tang. 2001. "Radio frequency and microwave alternative treatments for insect control in nuts: a review." *Agricultural Engineering Journal* 10 (3&4):105-120.

2) Al-Haj Ismail, A Yousif, and A. M. Mohammed. 2000. "Effect of the Kind of Microwave rays on Stored Products insects." *Mesoptamia Journal* 32 (1):101-106.

3) Halverson, William R, Timothy S Bigelow, and Steven L Halverson. 2003. "Design of a High Power Microwave Applicator for the Control of Insects in Stored Products." 2003 ASAE Annual Meeting.

4) Vadivambal, R, OF Deji, DS Jayas, and NDG White. 2010. "Disinfestation of stored corn using microwave energy." *Agriculture and Biology Journal of North America* 1 (1):18-26.

5) Al-Ebady, Emad Qasim, Nabil Mustafa Al-Mallah, and Haitham Muhi-Aldin. 2012. "The Application Of Microwaves Ray To Controlling The Adults Of Some Stored Grain Insects." *Journal of Kerbala University, Iraq* (Second Scientific Conference, College of Agriculture, Kerbala'a University, Iraq):1010-1016.

6) Saleh, Ali Basim. 2015. "Use of some Physical and Bio-pesticide for Fungus *Isaria fumosoroseus* controlling of the Lesser Grain Borer *Rhyzopertha dominica* (F.) (Coleoptera : Bostrichidae)." MSc., Plant Protection, University of Kufa.

7) Al-Matlabi, Ahmad Hasn Hadi. 2016. "Study of intensity and percentage infection of large wax worm Galleria mellonella (L) (Lepidoptera: pyralidae) in Maysan Government and the use of microwave rays in control." MSc., Plant Protection, Baghdad University, College of Agricultral Engineering Sciences.

8) Al-Hamadani, Alaa Hussien Abed. 2016. "The Use of Some Physical and Biological Control Methods for the control of the Grain Moth *Sitotroga cerealella* (Oliver) (Lipedoptera:Gelechiidae)." PhD., Plant Protection, University of Baghdad.

9) Kirkpatrick, ROBERT L. 1974. "The use of infra-red and microwave radiation for control of stored-product insects." Proc First Intl Conf Stored Prod Entomol. Savananah, GA.

10) Zaied Y., M., A. Almabruk, H., and S. Ghafir, A., M. 2002. "A Preliminary Study of the Effect of Microwave Radiation on Granary Weevil Sitophilus granarius (L.) (Coleoptera:Curculionidae)." *Arab Journal of Plant Protection* 20 (1):14-17.

11) Bedi-SS, and Major-Singh. 1992. "Microwaves for control of stored grain insects." *National-Academy-Science-Letters* 15 (6):195-197.

12) Watters, FL. 1976. "Microwave radiation for control of Tribolium confusum in wheat and flour." *Journal of Stored Products Research* 12 (1):19-25.