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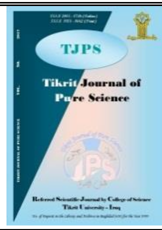

Effect Of Nd:YAG Laser On Flour Beetle

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Abstract

In this study we examined the effect of pulse Nd:YAG laser radiation on the flour beetle (*Tribalium castaneum*) in terms of changes in the external appearance of this insect (shape and color), and calculated the percentage of death rate due to Nd:YAG laser irradiation of wavelength (1064 nm) with energies: (260, 300, 340, 380 & 420)mJ and exposure times (10, 15 & 20)sec for each energy with (5 pulse/sec), when the distance was (20 cm) between the source of laser and the sample. The results showed an increase in the percentage of death of the flour beetle in addition to increasing distortions where the energy of laser increased and the exposure time increased, where the results of this laser treatment effect were taken in time stages: after (24 hours) and then note after pass (48 hours) and then (72 hours).

Introduction

The subject of biophysics is interdisciplinary and includes different fields of biology and physics. The contributions of scientists and experts from different places of the world focus on the main aspects of biophysics, which led to the development of technologies and applications in this field [1]. The most important technologies in this field is laser for its extensive applications in the fields of industrial, medical, biological, economic and agricultural [2]. (In this research laser was used in irradiation to influence the flour beetle to observe its effect on them and be able to benefit from it at the economic and health level).

The world suffers from economic and health damage caused by insects, whether in quantity or quality when attacking grain and materials during storage [3]. The flour beetle is one of the most important insect pests in many parts of the world [4], as it attacks many food products and is one of the most important insect which stores in homes and stores, which lead to a change in the chemical composition of the infected grain [3.5]. Despite the use of insecticides to protect crops and materials stored against harmful insects, there are problems related to the negative impact of pesticides on humans and animals and their adverse impact on the environment and pollution, as well as problems related to pest resistance to pesticides, which prompted researchers in the control of grain pests and stored materials to think and search for modern means of protecting insecticide-containing materials [4], the development of non-toxic, safe and effective alternatives was needed, leading to various advanced experiments and tests of vital effectiveness against invasion of store pests [6].

Theoretical

Lasers in biology and medicine have been used either as a diagnostic tool or for non-reversible change in the living cell or tissue. The primary purpose of this technique is to study the cell's function after the effect of the laser in a particular area of the cell, and the mutual influence between light and matter and that the energy produced by this effect can be precisely channeled from the use of biomaterials .

Nd:YAG laser is widely used in a variety of applications, including material treatment during manufacture, laser range determination and laser surgery [7]. Because of the multiple properties of laser, it is used in multiple techniques to benefit from its interaction with materials and rapid changes, where the interaction is based on two directions. Visual interaction depends on the wavelength of the laser used and on the extent of its interaction with the material and its compatibility with it in terms of absorption, this is called optical effect, and the other effect is the thermal effect which is the instantaneous effect of the thermal energy and according to the law of Stefan - Boltzmann:

$$E = \sigma T^4 \text{ .... (1)}$$

Where (σ) is the Stephan-Boltzmann constant, (E) total energy emitted from the body, (T) absolute

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temperature. These effects are effective and rapid due to the large temperature rise affecting small areas [8]. In order for the laser to have an effect on the material there must be an absorption of the laser beam [2,9], this absorption is very important for the reaction of the laser with the material, it is a primary source of energy within the material and is represented by the laser beam emitted from the source [2,10]. It can be said that the process of the interaction of the laser with the material includes heating the material and then absorption and distribution of energy [11]. The falling laser pulse warms up the target material quickly, causing a change in the phase, resulting in waves of stress in the irradiated target. It can be said that the process of the interaction of laser with the material includes heating the material and then absorption and distribution of energy [10]. The thermal reactions of the laser with the material is divided into several types, either an interaction that results in the heating or fusion or evaporation or it occurs plasma, and all these reactions occur as a result the ability of the material to absorb the light of the laser and the extent of change that can be caused by the characteristics of thermal and temperature melting and evaporation [12]. Laser work does not require vacuum technology or large space, the process is done without contact with the material, there are no specific specifications for the materials that can be treated by laser, and laser beam can reach places where other techniques are not accessible [13].
The interaction mechanisms that may occur when applying laser light to biological tissues are manifold. The specific laser properties and the laser parameters contribute to this diversity. Reflection, absorption and dispersion factors, as well as the thermal conductivity, are the most important characteristics of the optical tissue. In order for beam to have an effect on a specific tissue, it must be absorbed, if it is applied or reflected back, it has no effect on this tissue, in the case of dispersion it means absorbing it by a larger area of the tissue and spreading its effect and weakening it. On the other hand, the laser parameters affecting its interaction with the fabric are wavelengths, exposure time, energy intensity, spot size and exposure distance. Figure (1) shows the mechanism of reflection, refraction, absorption, and beam propagation within the tissue [8].

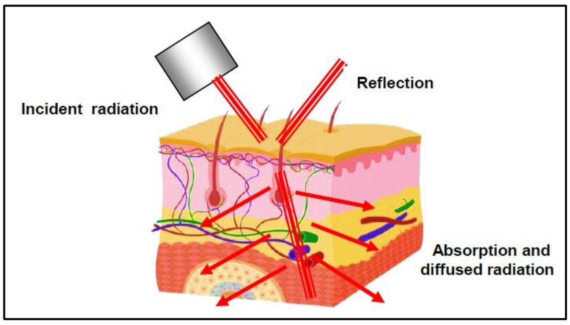

Figure (1): Mechanism Of Interaction Laser With The Tissue

The interaction of laser with the biological tissue has a local effect. All radiation energy can be given to the exposed tissue site and target. The process of interaction between laser and the biological tissue and the effect generated by the interaction depends on the characteristics of laser beam used and the tissue [13], laser converts energy into a heat that is absorbed by the processed tissue, part of it is evaporated and eliminated by evaporation of the water content in the cells, the remaining part is transferred to adjacent tissue where it is heated, hence the unwanted thermal effect in neighboring tissues [14]. The optical penetration depth of Nd:YAG lasers radiation is large, hence, major indications for this laser in dermatology are given by deeply located hemangiomas or semi malignant skin tumor. Figure (2) is showed the location of laser thermal effects inside biological tissue [8].

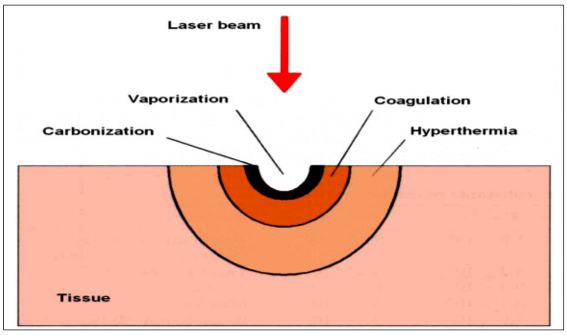

Figure (2): The Location Of Laser Thermal Effects Inside Biological Tissue

Experimental

In this research the adult insects were collected for the beetle from the infected flour and preserved at (25°C). The cultivation of the insect was based on whole wheat flour, which contains a high percentage of bran. Laboratory farms were equipped with 10 clean and sterile glass bottles, (10 g/bottle) was placed in flour, placed 10 pairs per flask and the bottles were covered with a sterile piece of gauze nozzle sleeves made of rubber material placed in the incubator at (30°C) and relative humidity (± 70%).
The pulse Nd: YAG laser (1064 nm) of irradiation distance (20 cm) were used to irradiate the samples collected and reared to observe the effect of changing some laser parameters by changing the laser energy as well as the time period for exposing the samples to laser radiation, where the samples were placed in petri dishes and exposed to radiation. Three groups were taken, and (260 mJ) was activated with a change in the irradiation time, with a section for (10 sec) and one for (15 sec) and a third for (20 sec). Then three other groups were lit at the same three period times but (300 mJ) irradiation energy. Three other groups irradiated by (340 mJ) at (10 sec), (15 sec) and (20 sec). Then the irradiation energy was changed to (380 mg) and the same exposure times, and finally the last three groups with the same irradiation times and energy (420 mJ) .

After that the external appearance of all samples which were exposed to laser; they were tested by using a camera filmed type (Sony) strongly enlarge (12 mega pixel).

Results & Discussion

The changes in the external appearance of the beetle (figure 3) were studied, as well as the calculation of death rates due to laser exposure at specific energies and time durations, the results were as follows:

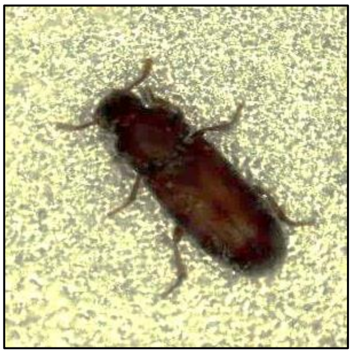

Figure (3): Flour Beetle Non treated By Laser

1 - Effect Of Laser On The External Appearance Of Flour Beetle

The study showed slight defects in the whole insect after being exposed to laser radiation for (10 sec) and all energies in general, where was observed the presence of black spots on the outer wall of the body with a tear to some legs of the insect during treatment, as shown in figure (4).

When the exposure time or laser treatment was changed to (15 sec), a stronger effect was observed compared to previous time on the external appearance of the insect. There was a change in the color of the outer wall from the red to that black with a clear rupture of the thoracic rings from the side of the insect's belly, in addition to that there was distortion of the horns of the sensor, as shown in figure (5).

When the insect was exposed for a period of (20 sec), the results showed a change in the body of the insect as a result of the proximity of the body rings and thus the shortness of the body compared to the untreated insect, in addition to complete blackening of the insect and the deformation of the chest area of the body of the insect and deformation in the legs, as shown in figure (6).

Figure (4): Flour Beetle Exposure to Laser for (10 sec)

Figure (5): Flour Beetle Exposure to Laser for (15 sec)

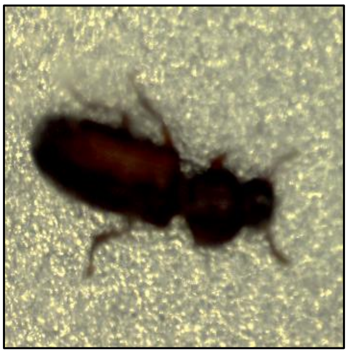

Figure (6): Flour Beetle Exposure to Laser for (20 sec)

These results obtained by laser treatment are similar to those obtained by previous research and studies, in which inactive powders were used, such as coal, calcium, copper sulfate, and others, which led to the erosion of the surface skin layer and thus exposing the insect to drought and death.

2- Effect Of Laser On Flour Beetle's Life

Table (1) shown the death percentage rates of flour beetle treated by laser with energies (260, 300, 340, 380 & 420)mJ and exposure durations (10, 15 & 20)sec.

Table (1): Death Percentage Rates Of Flour Beetle Treated By Laser

Irradiation Energy (mJ)	Duration of Irradiation (sec)	The Percentage of Insects Death After 24 Hours %	The Percentage of Insects Death After 48 Hours %	The Percentage of Insects Death After 72 Hours %
260	10	10	16.66	23.33
300	10	13.13	20	26.66
340	10	13.13	20	26.66
380	10	16.66	23.33	30.33
420	10	18.5	23.33	33.33
260	15	26.66	36.66	43.33
300	15	26.66	36.66	50
340	15	36.66	50	50
380	15	43.33	50	55.5
420	15	50	55.5	60.66
260	20	43.33	43.33	66.66
300	20	43.33	50	66.66
340	20	55.5	60.66	73.77
380	20	60.66	70	80
420	20	63.66	73.77	83.33

- **The Death Percentage Of Flour Beetles After (24 hours) Of Laser Treatment**

The percentages in table (1) indicate that there are significant differences in the effect of laser on the life of flour beetle after irradiation at duration times (10, 15, 20)sec. The results gave death rates at laser irradiation (260 mJ) noting that relative mortality rates are relatively stable or increased at a simple level at energies (300, 340)mJ, after which the rates of death rates increased when energy increased to (380 mJ), and the results showed that highest rate of death occurred at (420 mJ), as shown in figure (7).

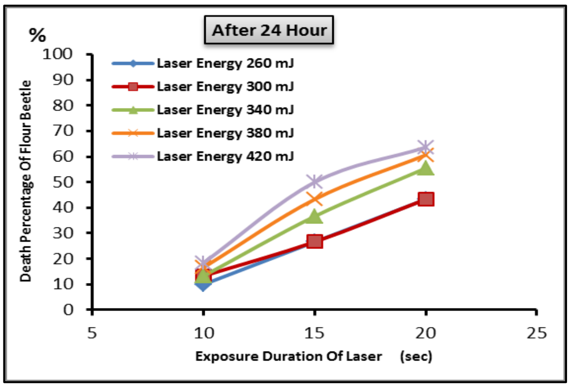

Figure (7): Percentage Of Flower Beetle Death After (24 houer) Treated By Laser

- **The Death Percentage Of Flour Beetles After (48 hours) Of Laser Treatment**

The results of table (1) show that the percentage of death after (48 hours) of laser treatment of flour beetle is higher than that for the (24 hours) case. The results showed higher rates of death at irradiation at the same duration times and with the same irradiation energies, note that these rates increase slightly at low energies and sometimes stable, and highest rates are obtained at (420 mJ), as shown in figure (9).

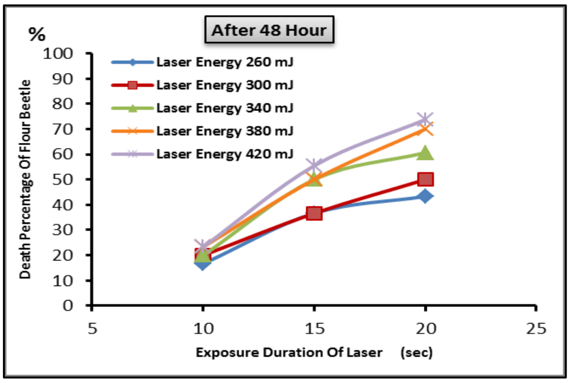

Figure (8): Percentage Of Flower Beetle Death After (48 hours) Treated By Laser

- **The Death Percentage Of Flour Beetles After (72 hours) Of Laser Treatment**

The results showed the highest mortality rates for flour beetle as shown in table (1). Also, lowest rates are obtained at energy (260 mJ) and highest rates are obtained at energy (420 mJ), as shown in figure (9).

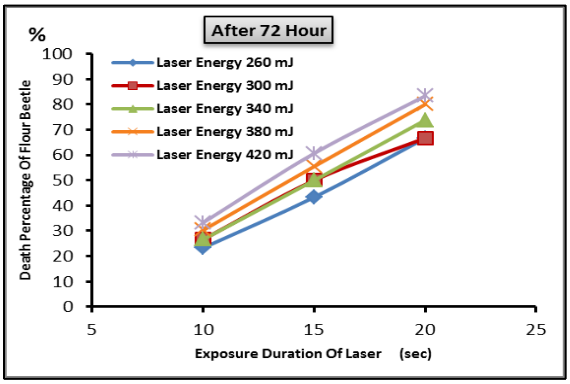

Figure (9): Percentage Of Flower Beetle Death After (72 hours) Treated By Laser

In general, the results showed that the mortality rates of flour beetle increased by increasing the exposure time of laser radiation after the calculated hours with stable energy of the exposure, and it increased by increasing the energy to be record its highest level when the energy reaches (420 mJ) and for all durations of laser exposure when compared to the exposure energies used in this research, as it shown in figures (10 - a, b, c, d, e, f).

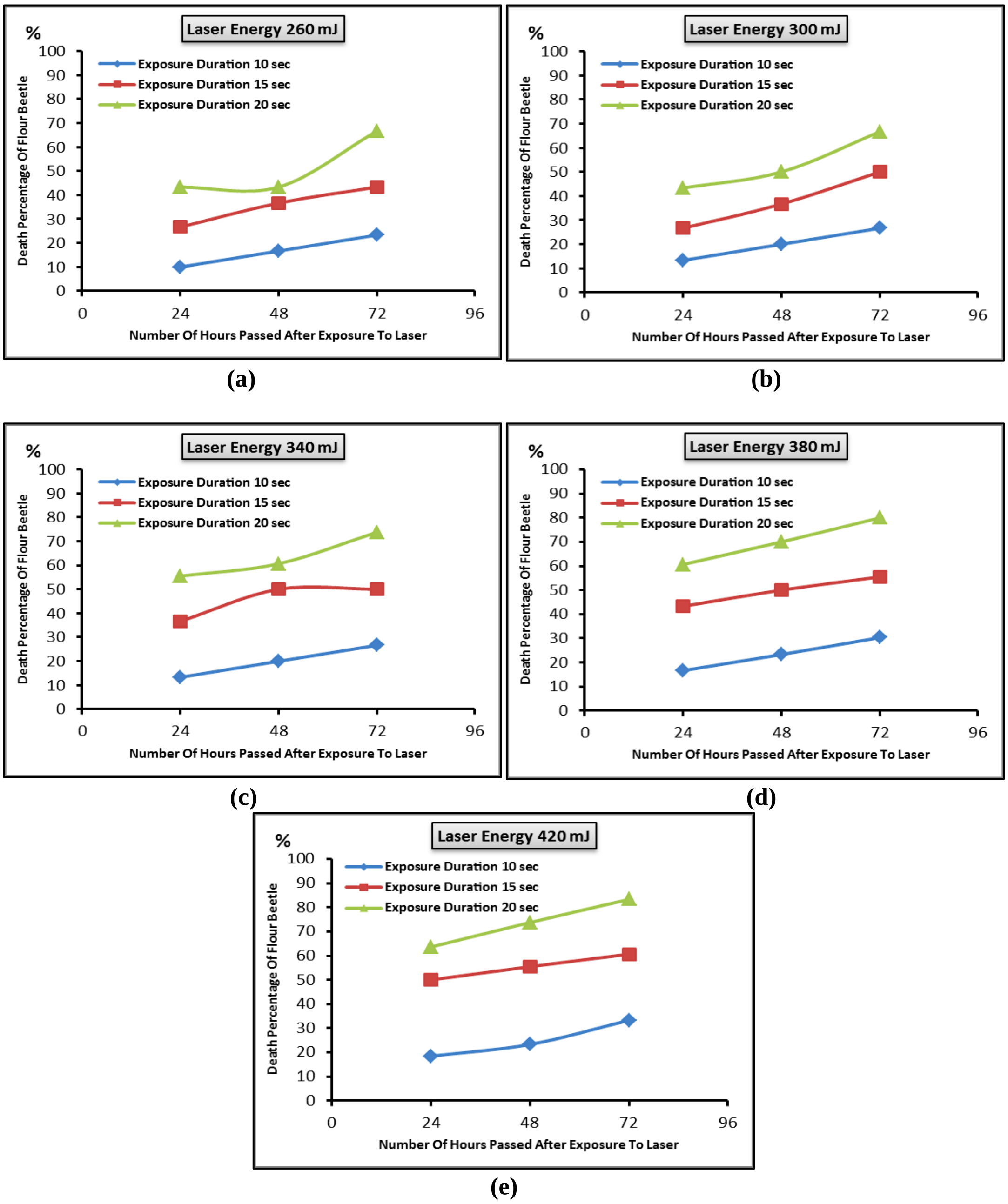

Figure (10): Percentage Of Flower Beetle Death Treated By Laser With Different Energies

Exposure to laser energy leads to a rise in the temperature of the exposed area. The results obtained for the percentage kill rates of the insect can lead to sharp changes in temperature due to increased exposure time or increased laser energy, which have direct effects on the insect, such as loss of water from the body and the imbalance of gases within the tissues of the insect body followed by a rapid breathing, causing high exchange of energy, and as the source [15] that such operations as a whole invokes imbalance and compatibility in the internal environment of the cell in the insect.

The wavelength of the Nd:YAG laser used (1064 nm) has high permeability in the water liquid of the insect, which leads to penetration of the outer envelope and penetration into the internal organs, which leads to damage, on the one hand; on the other hand, the increase in exposure time and energy and the close distance of the source of laser to the insect (20 cm) leads to an excessive increase in laser energy per unit area where the increase in energy efficiency for the unit area (surface of the insect) led to high heat in a very short time which in turn led to significant damage to the structure and appearance of the insect.

Conclusions

We conclude from this study that the laser can be used to make changes to the external appearance of the beetle in terms of color, shape and appearance of some deformities, as well as increase the percentage of death of this insect, this means that the laser can be used as an alternative to toxic pesticides, it is a safe, efficient and economical source of high temperature in its area without need for high energy to operate. The operational laser parameters can be changed by changing the energy and time of exposure, noting that the higher energies of laser had the greatest impact in terms of increasing the percentages of the death of insects in this research. Also, the close distance to the exposure source used in this research helped to happen these effects because the concentration process, i.e., laser beam excitation will be greater by close distance where the laser energy is distributed on a small area of the surface and therefore the effect is significant, so we recommend reducing distance between source and target in order to improve death rate.

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تأثير ليزر نيدميوم – ياك على خنفساء الطحين الصدئية

سحر ناجي رشيد

قسم الفيزياء ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

في هذا البحث تم دراسة تأثير اشعة ليزر نيدميوم – ياك النبضي على حشرة خنفساء الطحين الصدئية من حيث التغيرات التي طرأت على المظهر الخارجي لهذه الحشرة من ناحية الشكل واللون وكذلك حساب نسب القتل المئوية نتيجة التشعيع بليزر نيدميوم – ياك بطول موجي (1064 nm) وبالطاقات: (260, 300, 340, 380 & 420)mJ وبفترات تعرض زمنية لإشعاع الليزر (10, 15, 20)sec لكل طاقة وبمعدل (5 نبضة/ ثانية)، وكانت المسافة (20 cm) بين مصدر الليزر والعينة. وقد بينت النتائج زيادة نسب القتل المئوية لخنفساء الطحين اضافة الى زيادة التشوهات فيها كلما زادت طاقة الليزر وزمن التعرض للإشعاع، وقد تم ملاحظة نتائج تأثير المعاملة الليزرية هذه على مراحل زمنية: وهي بعد مرور (24 ساعة) ثم ملاحظتها بعد مرور (48 ساعة) ثم بعد (72 ساعة) .

الكلمات المفتاحية: ليزر نيدميوم – ياك ، تشعيع، فيزياء حياتية، خنفساء الطحين الصدئية، تفاعل الليزر.