Zagazig J. Agric. Res., Vol. 45 No. (6B) 2018 2433-2438

Soil Science and Agricultural Engineering

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

STUDY OF ULTRASONIC WAVES INFLUENCE ON *Spodoptera littoralis* BIOLOGY

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Received: 02/10/2018; Accepted: 11/11/2018

ABSTRACT: Chemical pesticides used as a quick solution for insects control. However, these pesticides lead to environmental pollution and residues on plants that reduce their safety and exporting chances, as well as the consequences of wrong use such as non-compliance with the recommended concentrations or following spraying precautions. Additionally, draft and run off problems in soil, water and neighboring crops which may meet it's harvesting time. So, this research aims to use and test ultrasonic technology as an environmentally friendly and cost-effective method that can be integrated without conflict with the integrated pest control chain for human safety, safe environment and agricultural exports flourish. This work proposed to study the influence of ultrasonic sound based technology on activity of *Spodoptera littoralis* insects. The experiment was conducted at Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt. The experimental procedure started by ultrasonic generator testing under spectrums range of 5 to 12.5 kHz which simulated the human ear for distances range of 2.5 to 40 m. The insects were divided to two groups: the first group was treated by ultrasonic waves for 3, 6 and 9 hours; the second group was the control treatment. The effect of ultrasonic on the insects was evaluated by continuously noticing their activity, movement and feeding. The obtained results showed that, the maximum reduction percentages of feeding rate were 57.5, 51.1 and 51.5% for instars of 4, 5 and 6, respectively. By continued observation, it is observed that, the insects gathered in a form of groups away from the feeding leaves. The T-test statistical analysis showed high significant effect of using ultrasonic waves on activity of insects. So, it is recommended to use ultrasonic as a safe and environmental method for insect control.

Key words: Chemical pesticides, environmental pollution, ultrasonic technology, pest control, *spodoptera littoralis*, ultrasonic waves, sound level.

INTRODUCTION

Although chemical pesticides have been beneficial in crop protection, relying totally on synthetic pesticides has resulted in unintended and unforeseen problems, not only in developing insect resistant to insecticides, but also other problems such as bringing up secondary pest outbreaks and polluting the overall environment **(Jamornmarn, 2000)**. The increased use of pesticides for control of crop pests has caused health hazards to the consumers.

Dissathaporn *et al.* (2002) indicated that pesticide residue has been an enormous problem in which restricts the export-oriented production systems. Therefore, it is of utmost importance to minimize the pesticide residue problem when producing vegetables for external markets. Thus, it is become necessary to promote research interest of environmentally safe new pest control methods on insect repellents in agricultural field. Hence, recently, research on insect's repellents increased steadily. A repellent is defined as a behavioral response to a stimulus **(Miller *et al.* 2009)** and the differences between behavioral

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responses can be subjective. Recently, we have begun to become aware of the term of "Ultrasonic Pest Repellent". Vibrational waves of frequencies above the range audible to the human ear (includes all frequencies of more than 20 kHz) are generally referred to as "Ultrasonic". Because ultrasonic is, for the most part, of the same nature as audible sound, the physics of its propagation are similar to those of audible sound. While ultrasonic waves behave similarly to audible sound waves, their very short wavelengths accentuate some of the basic properties of all sound waves *i.e.*, they are highly directional at the source and are easily diffracted. Diffraction effects or reflection effects are the result of the interaction between the dimension of the wavelength of the signal and the dimension of the obstacle. If the wavelength is smaller than the obstacle, the signal will bounce off the obstacle and create a sound shadow behind the object. If the wavelength is larger than the object, the signal will appear to bend around the object. Because ultrasonic waves have very short wavelengths in comparison with audible sounds, they tend to be easily diffracted and attenuated by obstacles.

Many reports and studies on the biological effects of ultrasonic have been investigated to support claims for the use of frequencies above 20 kHz to control pest populations. The use of ultrasonic waves to effectively repel, mitigate, or control populations of insects within structures has, to this time, still studying .

Jhaveri *et al.* (2009) verified that, ultrasonic noise performs insect repellent impact and also a decrease in the pairing as well as a reproduction of numerous pests. **Aflitto and DeGomez (2015)** proved that, the performance of ultrasonic pest control gadgets have a perfect, provisional and fleeting influence on pest populations using infrasonic and ultrasonic waves system to repellent the insect which is harmful both for human and crops.

The advantinstars of ultrasonic pest repellers are environmentally friendly and neither contains any health risk to users nor any chemicals. Humans cannot hear frequencies of ultrasonic, so ultrasonic pest repellers do not disturb nearby users in any way. Therefore, in an attempt to reduce using of chemical pesticides, this work proposed to study the influence of ultrasonic waves based technology on the behavior of *Spodoptera littoralis* aiming to use ultrasonic waves to resist insects using a tested ultra-sonic generator.

MATERIALS AND METHODS

The experiment was carried out during 2017 at Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt to study the influence of ultrasonic waves on activity of *Spodoptera littoralis* as an environmental method for insect's pest control.

Materials

Ultrasonic generator

An ultrasonic generator (model M071N – Germany industry – Fig. 1) was used to produce pulsating and aggressive ultrasonic sounds like a siren which many pests perceive as extremely unpleasant and, therefore, try to avoid as far as possible. The frequency of the generator is adjustable between approximately 8 to 40 kHz (±15%) by 7marks-adjusting regular switch (A, B, C, D, E, F and G). The operating voltinstar is 12 VDC (10-13.8 V). Range distance < 40 m with free field. The generator was powered by a 12 VDC-8 Ah battery.

Spodoptera littoralis

The insects from laboratory of the Plant Protection Research Institute (PPRI) were presented in groups of *Spodoptera littoralis* larvae at 4^{th}, 5^{th} and 6^{th} instars. These instars are the most severely and daminstard to plants. The diet was presented from castor plant leaves (circles with diameter of 5cm and fixed weight 10g).

Digital balance

A digital balance with resolution of 0.01g was used to weight the castor leaves before and after each treatment to estimate the larvae feeding.

Methods

The experimental procedure started by ultrasonic generator testing. So, the ultrasonic generator was tested at a reverberation room using sound level meter (Model of B&K 2260 Denmark) to estimate sound pressure for the 7marks-adjusting regular switch (A, B, C, D, E, F and G)

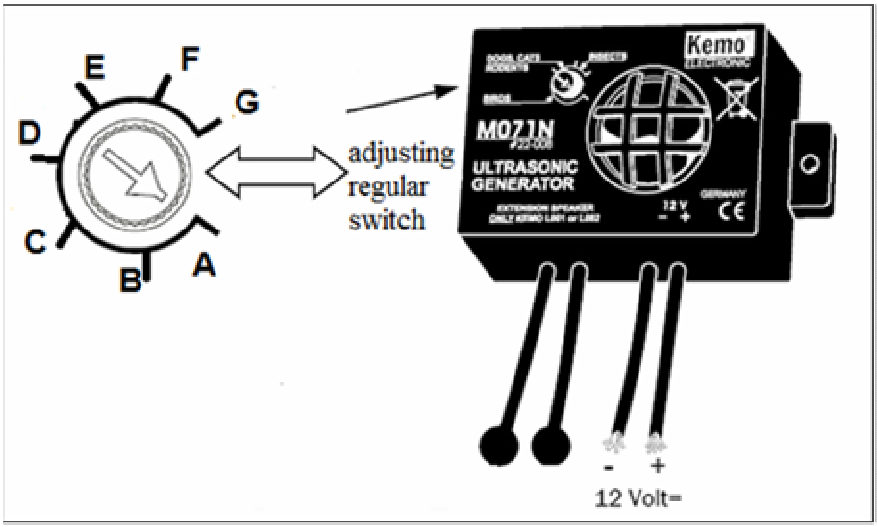

Fig.1. The ultrasonic generator

of ultrasonic generator and estimate the best mark for insects without nosing the human hearing (ultrasonic waves). The measuring device was set in five spectrums that simulated human ear at 5, 6.3, 8, 10 and 12.5 kHz. The distances between the generator and the sound level-measuring device were 2.5, 5, 10, 20 and 40 m. In addition, the 7-marks of generator were calibrated in physics laboratory of Faculty of Sciences, Cairo University using a digital oscilloscope device (Model of CA9040/CALTEK up to 40 MHz), and estimated as; A=5.8kHz, B=6.6kHz, C=10kHz, D=16kHz, E=25kHz, F=31kHz and G=38kHz.

After that, the obtained results of testing ultrasonic generator estimated the best marks of ultrasonic-operating of the generator in the experiment. Therefore, the experimental procedure was investigated by marks (E, F and G) of adjusting regulator of ultrasonic generator.

The larvae of *Spodoptera littoralis* (4^{th}, 5^{th} and 6^{th} instars) were divided in plastic containers to two groups: the first group was treated by ultrasonic waves from the ultrasonic generator extended to 3 periods (3 hours/period); the second group was the control treatment (was maintained far > 40m away to not subject to ultrasonic waves). The effect of ultrasonic on the insects was evaluated by continuously noticing their activity, movement and weight the leaves of castor plant for the first and the second groups before and after treatments. The obtained data was statistically analyzed by Excel program using paired T-test **(**according to **Snedecor 1970).**

RESULTS AND DISCUSSION

The obtained results were discussed under the following heads:

Sound Pressure of Ultrasonic Generator for Different Sound Spectrums Frequencies

Fig. 2 showed the results of sound level pressure in decibel (dB) obtained from testing ultrasonic generator for distances range of 2.5 to 40 m and sound spectrums range of 5 to12.5 kHz. Results showed that, the sound pressure decreased by increasing of frequencies of ultrasonic waves from generator (by adjusting regulator switch). Otherwise, the sound pressure decreased by increasing the distance between the generator and the measuring device through for all sound spectrums. From testing procedure it is observed that, the highest levels frequencies of the used generator were unheard by the sound level measuring device which confirms that they non effective on human thus, using this generator is safe and environmental.

The results estimated that, the ultrasonic marks of adjusting regulator of the generator that were E, F and G. So, those marks were used for insect control whereas it didn't generate any sound noise for all distances except for 2.5 m and it was low value of only 31-36.8dB. According to (**Fausti *et al.*, 2005**), the handle limits of decibels for the human ear can describes as the maximum safe exposure time should be 4 hours for a 90 dB sound and 7.5 minutes for a 120 dB sound). While the

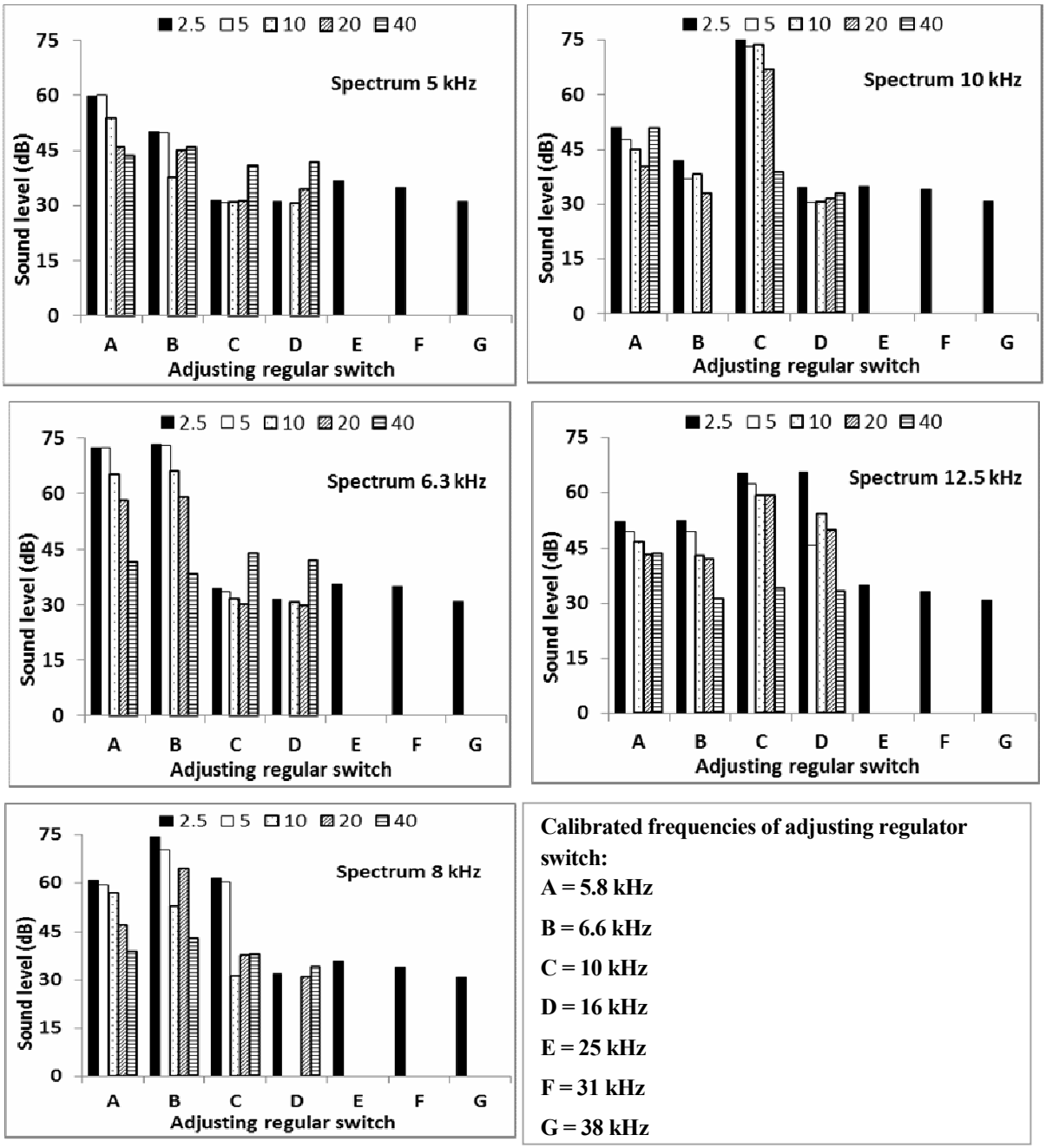

Fig.2. Sound level pressure of testing the ultrasonic generator for different distances and sound spectrum frequencies

sonic switch marks (A, B, C and D) causes sound levels lower than 90 dB. Whereas the mark (A) causes sound level ranges between 43.7 to 60.1, 41.7 to 72.5, 38.8 to 61.1, 40.2 to 51 and 43.1 to 52.2 dB at sound spectrum frequencies of 5, 6.3, 8, 10 and 12.5 kHz, respectively. The switch mark (B) causes sound level ranges between 37.7 to 50, 38.3 to 73.2, 42.9 to 74.3, 32.7 to 41.9 and 31.1 to 52.5 dB at sound spectrum frequencies of 5, 6.3, 8, 10 and 12.5 kHz, respectively. The switch mark (C) causes sound level ranges between 30.9 to 41, 30.3 to 44, 31.2 to 61.6, 38.6 to 78.8 and 34 to 65.4 dB at sound spectrum frequencies of 5, 6.3, 8, 10 and 12.5 kHz, respectively. The switch mark

(D) causes sound level ranges between 30.9 to 42, 30 to 42.3, 30.7 to 34.1, 30.4 to 34.5 and 33.1 to 65.7 dB at sound spectrum frequencies of 5, 6.3, 8, 10 and 12.5 kHz, respectively.

Influence of Ultrasonic Waves on Feeding of *Spodoptera littoralis*

The obtained results (Fig. 3) showed the effect of ultrasonic waves on feeding of *Spodoptera littoralis* larvae (in grams for each 100 insects) for instars of 4^{th}, 5^{th} and 6^{th} for three subjected sequentially periods (3 hours/period). The results showed decreasing in the feeding rate of insects that subjected to ultrasonic waves compared to control for all instars of larvae. The maximum reduction percentages of feeding rate were 57.5, 51.1 and 51.5% for instars of 4, 5 and 6, respectively. The average reduction percentages (at frequencies of 25, 31 and 38 kHz) were (14.2, 35.8 and 39.2%); (9.9, 31.2 and 41.1%); and (34.3, 46 and 22.3%) for 4^{th}, 5^{th} and 6^{th} instars, respectively. By continued observation, with increasing time of treatment, it observed that, some insects failed alienation and dead at the last day of instar (see Fig. 4). It was also noticed that, the insects had tried to far out from the container and and gathered in a form of groups away from the feeding leaves with slow motion. The statistical analysis confirmed that, it was be a significant difference between the insects treated by ultrasonic and the insects didn't treated. Whereas, the variance of feeding amount of insects in case of using ultrasonic compared to control treatments using paired T-test is noticed. As a result, Excel calculates the correct P value (P(T<=t) two-tail), which is 6.354E-07< $\alpha_{0.01}$. Therefore, it can be concluded that, the obtained results gave an indicator to the positive effect of ultrasonic waves on the insect's activity.

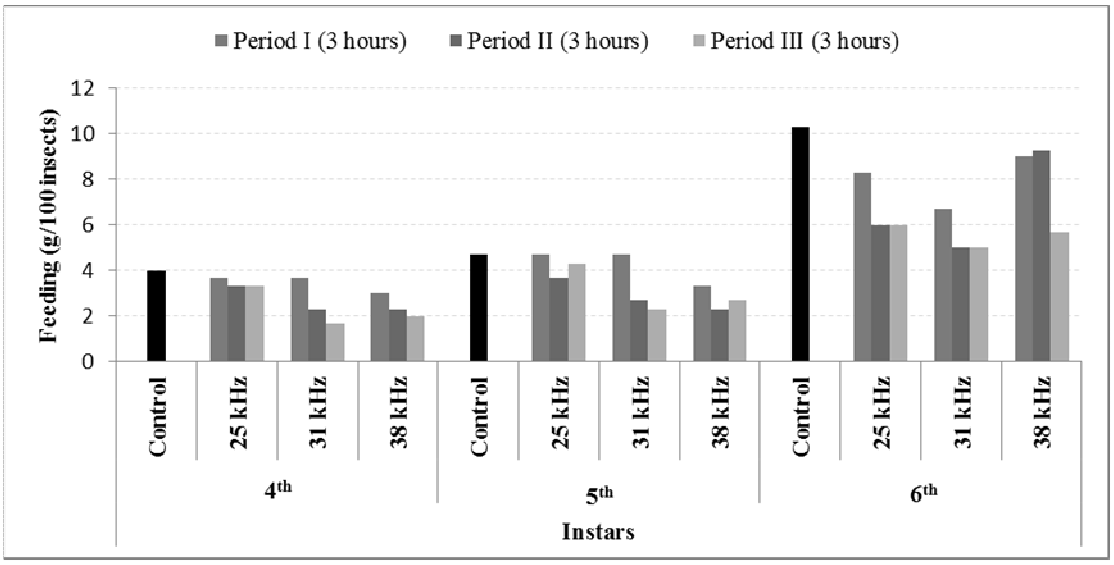

Fig. 3. The effect of ultrasonic waves on feeding insects

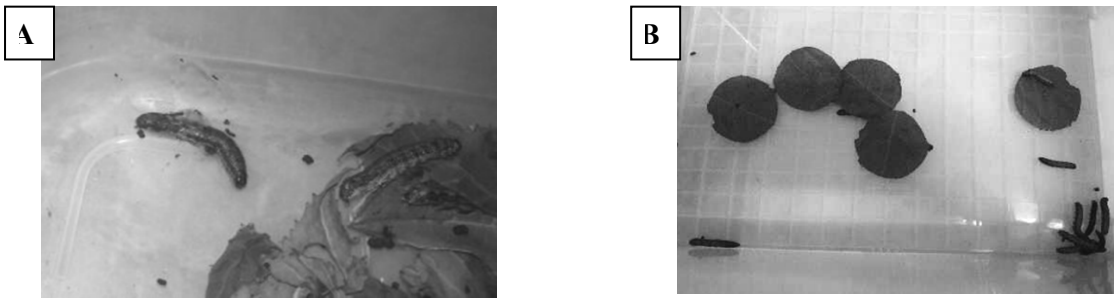

Fig. 4. The effect of ultrasonic waves on insect's activity; A) Failed alienation and death of insects B) Troubling of ultrasonic waves of insects by trying stay away and escaping

Conclusion

Based on the obtained results above in this study, it is recommended to use ultrasonic waves for insect control as an effective, safe and environmental method. Whereas there was a good effect of ultrasonic on the insects showed on their activity, movement and feeding. The T-test statistical analysis confirmed that.

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دراسة تأثير الموجات فوق السمعية على الصفات الإحيائية لدودة ورق القطن *Spodoptera littoralis*

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اعتاد المزارعون استخدام المبيدات الكيماوية كحل سريع للتخلص من الآفات ولكن مقارنةً بما تسببه هذه المبيدات من تلوث بيئي وترك آثار متبقية على النباتات تقلل من سلامتها ومن فرص قبولها كصادرات زراعية فضلاً عن النتائج الوخيمة للإستخدام الخاطئ كعدم الإلتزام بنسب التركيز المصرح بها أواتباع الإحتياطات الموصى بها بالإضافة لمشاكل جريان المبيد من فوق أوراق النبات للتربة والإنجراف إلى المجارى المائية والمحاصيل المجاورة والتى قد يتزامن موعد الرش مع وقت حصادها، لذلك يهدف هذا البحث إلى إستخدام وإختبار تقنية الموجات فوق السمعية لمكافحة دودة ورق القطن كطريقة صديقة للبيئة وموفرة للتكاليف والتى يمكن إدراجها دون التعارض مع سلسلة مكافحة للآفات متكاملة وآمنة لسلامة الإنسان والبيئة وإزدهار الصادرت الزراعية، ولتحقيق هدف البحث تم دراسة تأثير إستخدام تقنية الموجات فوق السمعية على نشاط يرقات حشرة دودة ورق القطن (*Spodoptera littoralis*)، وأُجريت التجربة في معامل كلية الزراعة ، جامعة الزقازيق ، محافظة الشرقية ، مصر، حيث تم اختبار مولد للموجات فوق السمعية فى مدي للأطياف الموجية يتراوح بين ٥ و ١٢,٥ كيلوهرتز لمسافات تتراوح بين ٢,٥ و ٤٠ متراً، وتم تقسيم مجموعات الحشرات المختبرة (لأجيال ٤، ٥ و ٦) إلى مجموعتين: المجموعة الأولى تم معاملتها بالموجات فوق السمعية لثلاث فترات متتالية (٣ ساعات/فترة)، المجموعة الثانية كانت غير معاملة للمقارنة بدون موجات فوق سمعية، تم تقييم تأثير الموجات فوق السمعية على الحشرات من خلال الملاحظة المستمرة لنشاطهم وحركتهم ووزنهم وتغذيتهم، وأظهرت النتائج المتحصل عليها وصول أعلي نسب انخفاض فى معدلات التغذية إلى ٥٧,٥، ٥١,١ و ٥١,٥% لأجيال ٤ ، ٥ و ٦، على الترتيب، ومن خلال الملاحظة المستمرة ،ُلوحظ وجود تكتل لليرقات فى مجموعات متلاصقة بعيدا عن اوراق التغذية ، كما أظهر التحليل الإحصائي باستخدام اختبار T أن هناك تأثير وفرق معنوي جداً لإستخدام الموجات فوق السمعية على نشاط الحشرات، لذا، ُ توصي الدراسة باستخدام الموجات فوق السمعية كوسيلة فعالة وآمنة وبيئية لمكافحة الآفات الحشرية.

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