



ANALYSIS OF THE EFFECT OF ULTRASONIC WAVES IN COMBATING THE WHITEFLY PEST IN GREENHOUSE CONDITIONS

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Abstract: *Insects that damage plants in greenhouse conditions negatively affect crop yields. This study investigates the effect of ultrasonic waves as an environmentally safe method of pest control. During the research, various frequencies, intensities, durations, and distances were tested to determine the maximum effectiveness of ultrasound on the whitefly, and their effects on the insect's activity, reproduction, and habitat were analyzed. The results confirmed that ultrasonic technology can be used effectively against pests without chemical agents.*

Keywords: *Ultrasonic wave, pest insect, whitefly (*Bemisia tabaci*), frequency, intensity, duration, distance.*

INTRODUCTION

The development and implementation of energy- and resource-saving, high-performance technologies and technical equipment for protecting plants from pests in greenhouse conditions is a global priority [1]. Considering that "67-70 million tons of tomatoes, 28-48 million tons of cucumbers, and 10-20 million tons of other vegetables" [2] are grown worldwide, establishing effective protection for these crops against pests is a crucial task [3]. Therefore, significant attention is being paid to developing highly efficient, energy- and resource-saving technical equipment and devices for protecting plants from pests in greenhouse environments [4].

In the republic's agricultural sector, comprehensive measures have been implemented to reduce labor and energy consumption, conserve resources, cultivate crops using advanced technologies, and develop high-performance agricultural machinery. In particular, special attention is being paid to producing technical equipment that increases the efficiency of technological processes with low energy consumption while protecting plants from harmful insects in greenhouse conditions [5]. This study analyzes how ultrasonic signals at different frequencies, intensities, distances, and durations affect pest activity and evaluates their effectiveness.

Materials and Methods of the Study. The following were adopted as the main factors influencing the effect of



ultrasonic waves on biological objects, specifically on insect pests in greenhouses or open fields: frequency (f), intensity (I), exposure time (t), and distance (l).

The study of the effects of the main factors in combating insect pests using ultrasonic waves was conducted using the classical method. In this approach, one factor was varied while the other three factors were kept fixed. The results of the conducted research were processed and presented in graphical form.

In the experimental model, considering that $k_1=0.1-1$ represents the average sensitivity level, $k_2=1.2\text{ m}^{-2}$ is the average value corresponding to a real-world environment, and $\sigma=5-10$ is the accepted biological range, the values $k_1=0.1$, $k_2=1.2$, and $\sigma=5-10$ were adopted [6, 7]. Additionally, since a significant physiological reaction was observed after 30 minutes of exposure, the observation duration for the experiments was set to 30 minutes.

Experimental studies were conducted by exposing greenhouse whiteflies to ultrasonic waves. The first experiment was performed by varying the frequency (f) while keeping the other factors - such as intensity (I), exposure time (t), and distance (l) - constant.

Figure 1 shows graphs of the plant protection level against whiteflies as a function of frequency at various distances.

A strong correlation was found between the frequency of the ultrasonic wave and the pest elimination efficacy. For the whitefly, efficacy reached its maximum value across all tested distances when the exposure frequency was in the 30-36 kHz range. Specifically, the highest efficacy for each distance was observed when the exposure frequency reached a value of 34.5 kHz. At this frequency, the efficacy rates, depending on the distance, were approximately 88% at 5.0 meters, 65% at 8.0 meters, 45% at 10.0 meters, and 35% at 12.0 meters.

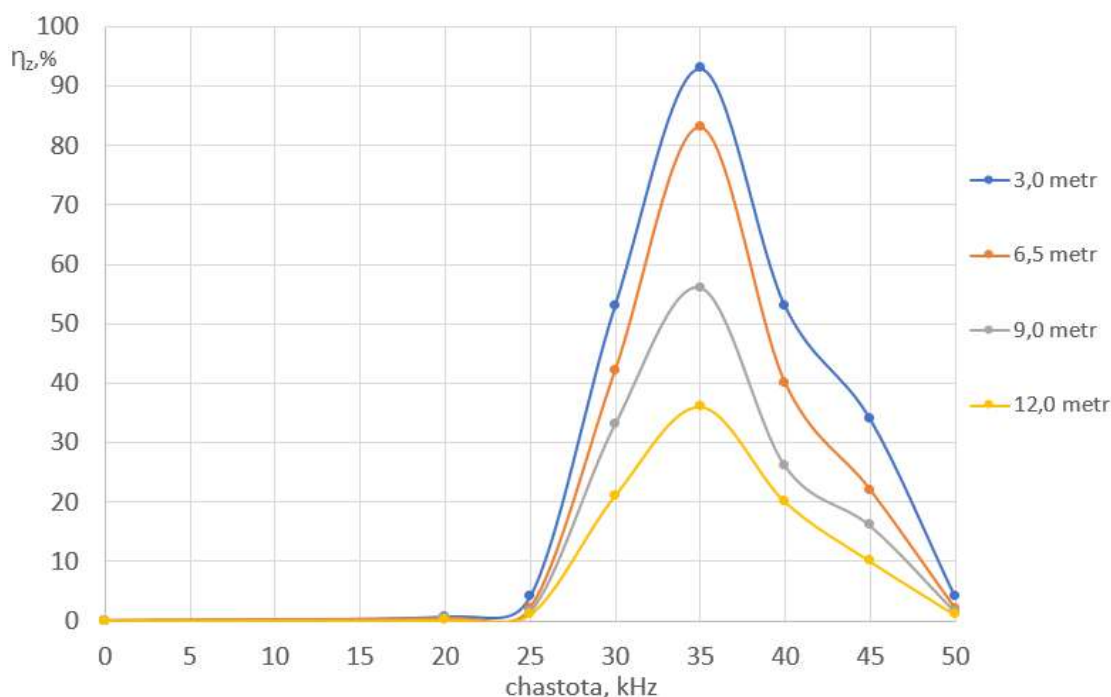


Figure 1. Graphs showing the change in the level of plant protection (η_z) from the whitefly at various distances (l) as a function of frequency (f).

As the distance increased, the efficiency decreased sharply. This demonstrates the effects of attenuation and absorption during the spherical propagation of ultrasonic waves. The experiment showed that the effect was maximal when the distance between the device and the plant was 5.0 meters, and the efficiency dropped to 35% or less when it exceeded 12.0 meters. At frequencies from 0-26 kHz and above 40 kHz, the efficiency was less than 10%, meaning there was almost no effect. This indicates that this frequency range is outside the whitefly's range of sensitivity.

The 30-40 kHz frequency range stands out as the zone that provides the highest efficiency in pest control. From this, it can be concluded that frequency selection and device placement are among the crucial factors in designing ultrasonic devices for pest control.

In the second experiment, the exposure time (t) was varied, while the frequency (f), intensity (I), and distance (l) were kept constant. Figure 2 illustrates graphs showing the change in the level of plant protection from the whitefly over time at different frequencies.

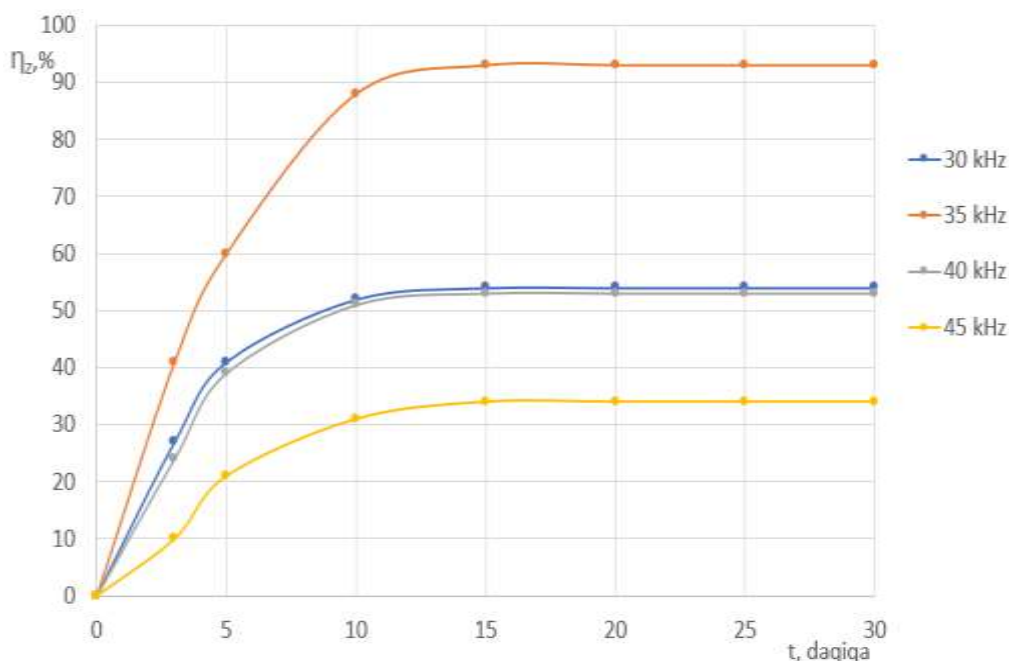


Figure 2. Graphs showing the change in the level of plant protection (η_z) from the whitefly at different frequencies (f) as a function of time (t).

As shown in the graphs in Figure 2, the effectiveness of the impact on the whitefly pest at each frequency increased sharply in the initial minutes and more slowly thereafter. After 30 minutes, the effectiveness plateaued and stabilized (transitioned to a steady state). At the 30-minute mark, the effectiveness at each frequency reached its maximum level and then stabilized, indicating the limit of the exposure time and a state of adaptation or saturation in the whitefly pest. The greatest increase in effectiveness across all frequencies occurred within the 0-5 minute interval. This represents the rapid

ultrasonic stimulation phase. The graphs show that ultrasonic bioeffects occur within a short period. Once the duration of the effect becomes stable, effectiveness no longer increases, but energy consumption does. This indicates the need to optimize the exposure time.

In the third experiment, the distance (l) was varied, while the frequency (f), intensity (I), and exposure time (t) were held constant. Figure 3 shows graphs of the change in the degree of plant protection from whiteflies as a function of distance at different frequencies.

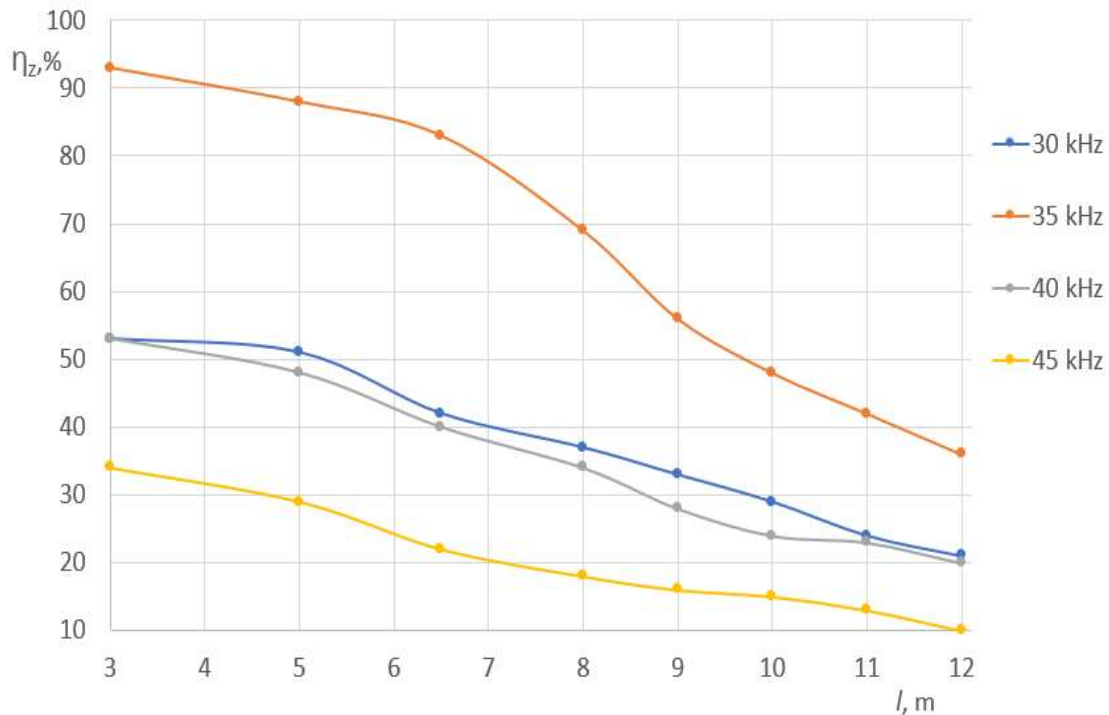


Figure 3. Graphs of the degree of plant protection (η_z) from whiteflies at different frequencies (f) as a function of distance (l).

As can be seen from the graphs in Figure 3, the efficiency steadily decreases at all frequencies as the distance increases in the conducted experiments. This is due to the spherical propagation and absorption of the ultrasonic waves. In the range from 3.0 m to 12.0 m, the efficiency decreased sharply. After 8.0 m, the decrease slowed, meaning the main loss of wave energy occurs within the first few meters. The effective range of ultrasonic waves is significant at

distances up to 10.0 meters; beyond 12.0 meters, the efficiency dropped below 35%, which defines the practical limit of use.

The graphs depicted in Figure 3 confirm the attenuation of ultrasonic energy, consistent with physical laws $I(l) \approx e^{-kl^2}$ yoki $I \propto 1/l^2$). When optimizing the device's parameters, the frequency, intensity, and distance must be optimized together.

Figure 4 shows graphs of the change in the degree of plant protection from the whitefly at different frequencies as a function of intensity (at a distance of 3.0 meters).

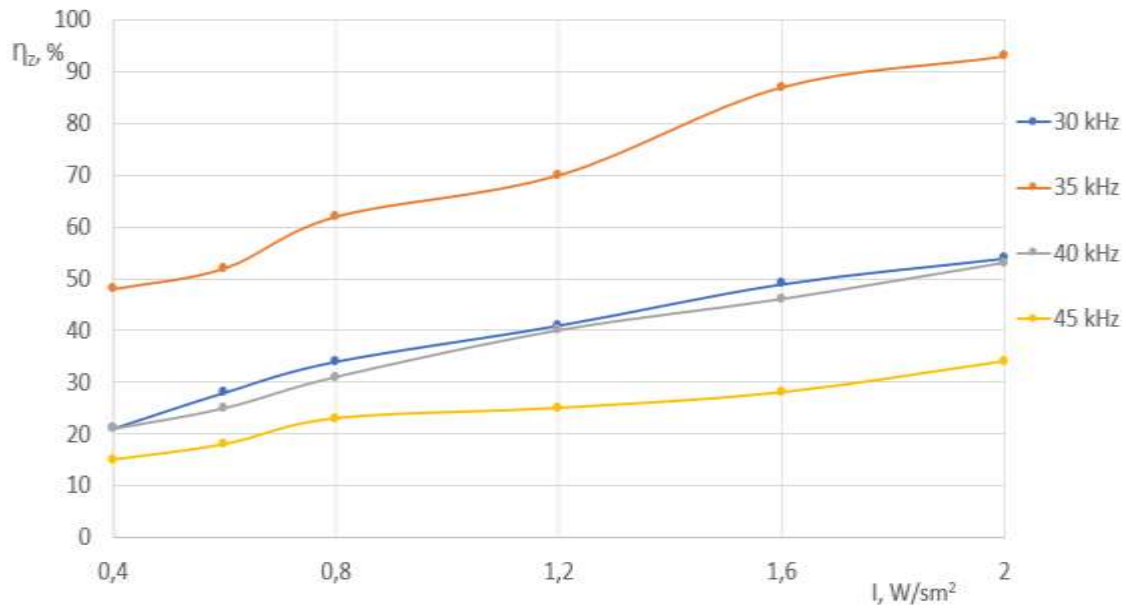


Figure 4. Graphs showing the change in the degree of plant protection (η_z) from the whitefly at different frequencies (f) as a function of intensity (I).

Figure 5 shows graphs of the change in the degree of plant protection from the whitefly at different frequencies as a function of intensity (at a distance of 8.0 meters).

At all frequencies, as the intensity of the ultrasonic wave increased, the level of plant protection from pests also increased. This confirms that as the ultrasonic energy increases, its effect on the whitefly pest is amplified. As the intensity of the ultrasonic wave increased to 1.5 W/cm², the level of plant protection from pests also rose. At this wave intensity, the whitefly insects are highly sensitive to the energy.

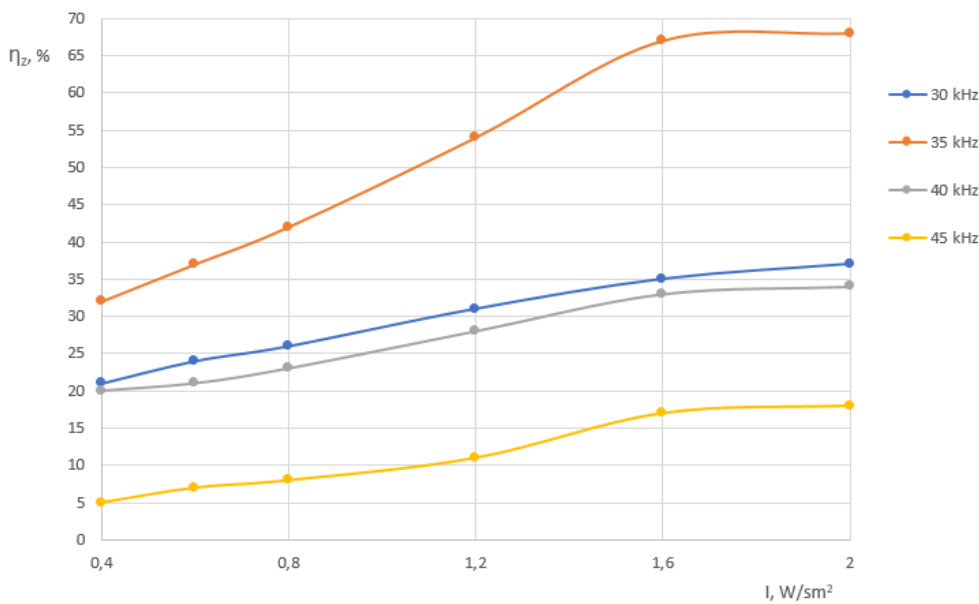


Figure 5. Graphs showing the change in the level of plant protection (η_z) from the whitefly (f) in relation to intensity (I).



Figure 6 illustrates graphs showing the change in the level of plant protection from the whitefly at different frequencies in relation to intensity (for a distance of 12.0 meters).

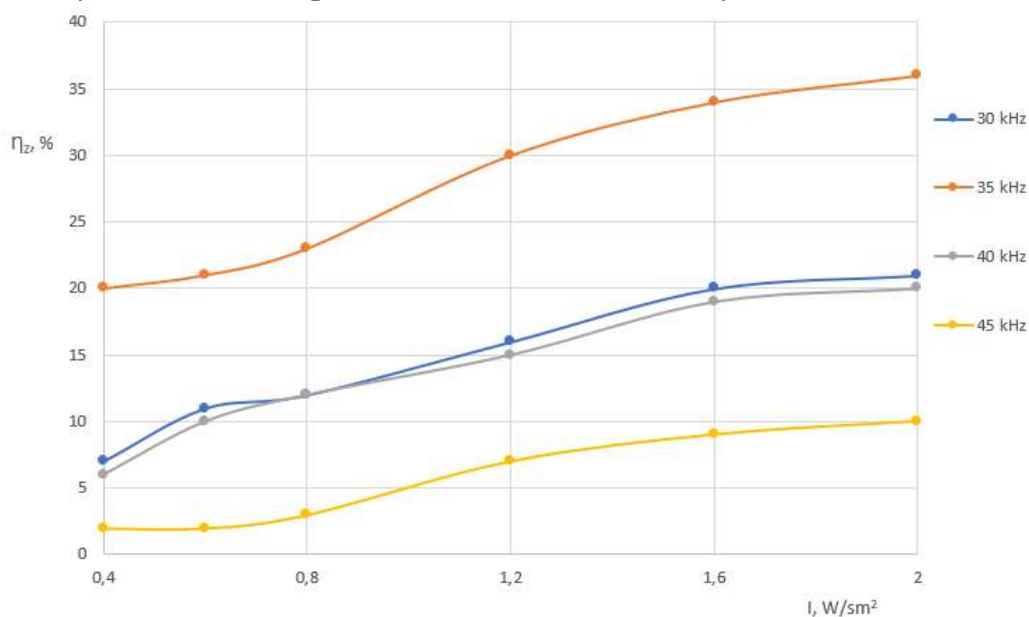


Figure 6. Graphs showing the change in the level of plant protection (η_z) from the whitefly at different frequencies (f) in relation to intensity (I).

In the wave intensity range of 2.0-3.0 W/cm², the level of plant protection from pests begins to increase slowly; however, negative effects on the plants were observed at this intensity. By increasing the wave intensity above 2.0 W/cm², the sensitivity of the whitefly insects to ultrasound decreased. Increasing the intensity of the ultrasonic wave above the 2.0 W/cm² value led to an increase in energy consumption.

As shown in the depicted graphs, the efficiency indicator does not change linearly. As the intensity of the ultrasonic wave increased, so did the level of plant protection from pests; however, after the intensity exceeded a certain value, the rate of increase in the protection level slowed down due to the saturation effect in whiteflies. Optimal frequency (f) and intensity (I) are important parameters for

maximizing efficiency in ultrasonic pest control technology. The graph in Figure 5 shows that as the distance increases (3.0 m → 12.0 m), the overall efficiency decreases, which is based on the physical law that an ultrasonic wave loses energy along its path. Intensity must be taken into account when designing the device.

Conclusion: The research results revealed that ultrasonic waves, one of the electrotechnological methods, are highly effective in reducing the number of pests in greenhouse conditions. This method not only provides effective pest control but also increases the plant growth rate and improves productivity. The results obtained in the experiments confirm that this electrotechnology is environmentally safe and efficient, which creates significant opportunities for its widespread application in agriculture.



REFERENCES:

1. H. Yalcin, "Vision based automatic inspection of insects in pheromone traps," *Agro-Geoinformatics (Agro Geoinformatics)*, Fourth International Conference on, Istanbul, pp. 333-338, 2015.
2. Bobojanov Yu.M., Eshpulatov N.M., Khamidov Yu.K. THE EFFECT OF ULTRASOUND ON THE HEALTH OF WORKERS. *Science and Education in Karakalpakstan*. 2023 No4/1 ISSN 2181-9203.
3. Subhodip Maulik, "Realization of low cost Bluetooth based visual sensor node for pest and disease detection in crops," *International Journal of Emerging Technology and Advanced Engineering*, Vol. 2, Issue 6, pp. 92-97, June 2012.
4. Potamitis, I., Ganchev, T., Fakotakis, N., "Automatic acoustic identification of insects inspired by the speaker recognition paradigm," In *Interspeech*, Pittsburgh, Pennsylvania, pp. 2126-2129, 2006.
5. Dr. S. Thangalakshmi, R. Ramanujan, "Electronic Trapping and Monitoring of Insect Pests troubling Agricultural Fields" *International Journal of Emerging Engineering Research and Technology*, Vol. 3, Issue 8, pp. 206-213, August 20.
6. Nayan Roy, "Phytochemicals in the sunflower, *Helianthus annuus* L. (cv. PAC-36) and their role in the interactions with defoliator, *Diacrisia casignetum* Kollar (Lepidoptera: Arctiidae) ," *Department of Zoology*, 2013.
7. Chien, L. C., et al. (2010). Ultrasonic waves for insect pest management. *Journal of Applied Entomology*.