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ANALYSIS OF ANATOMICAL AND MORPHOLOGICAL CHANGES IN PLANTS UNDER UV-C RADIATION TREATMENT AGAINST APHID INFESTATION

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Abstract:*This article presents a scientific analysis of the anatomical and morphological structure of aphids, which are among the major pests affecting plants, as well as their negative impact on plant organisms. The feeding behavior of aphids on vegetative plant organs leads to disruption of photosynthesis, transmission of viral diseases, and reduction in crop productivity. In addition, the effects of ultraviolet (UV) radiation, particularly in the UV-C and UV-B ranges, on insect organisms were examined, focusing on damage to both external (exoskeleton) and internal systems (nervous, digestive, and visual systems). The results indicate that UV radiation can disrupt cellular structures, thereby inhibiting the growth and reproduction of aphids. This method is considered environmentally safe and effective, offering a promising alternative to chemical insecticides.*

Keywords*:* *Aphids, ultraviolet radiation, UV-C radiation, plant diseases, anatomical structure, morphological structure, pests, ecological methods*

INTRODUCTION

Plant diseases and pests are among the primary factors leading to a significant reduction in agricultural productivity. Aphids, in particular, feed on the vegetative parts of plants, disrupting physiological processes, reducing photosynthetic activity, and facilitating the transmission of viral diseases. As a result, plant growth is inhibited and crop quality deteriorates.

Traditionally, chemical insecticides have been widely used to control such pests. However, their long-term application can lead to environmental pollution, destruction of beneficial organisms, and negative effects on human health. Therefore, the development of environmentally friendly, efficient, and innovative pest control methods has become increasingly important.

In recent years, ultraviolet (UV) radiation technology has emerged as a promising approach in pest management. In particular, UV-C (100–280 nm) and UV-B (280–315 nm) radiation possess high energy capable of damaging cellular structures, DNA molecules, and physiological systems of insects, thereby inhibiting their growth and reproduction.

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Anatomy and Morphology of Insects Plant diseases represent complex pathological processes caused by various etiological factors, including pathogenic organisms and unfavorable environmental conditions. These processes disrupt essential physiological functions of plants, such as photosynthesis, respiration, synthesis of growth substances, and the transport of water and nutrients. As a result, the overall vitality of the plant is impaired, which may lead either to partial damage of specific organs or, in severe cases, to complete plant death. To date, more than 30,000 types of plant diseases have been identified. These diseases are commonly classified based on their symptoms (pathographic classification), the type of affected plant, and the causative agents. According to etiological classification, plant diseases are divided into infectious and non-infectious types. Infectious diseases are primarily caused by various pathogens, including insect pests that act as vectors. Among infectious diseases, viral infections include mosaic diseases, wilting, dwarfism, and tissue proliferation; bacterial diseases (bacterioses) include plant cancer, bacterial rot, and bacterial blight; while fungal diseases (mycoses) include rust, smut, fusariosis, and various forms of decay. Therefore, this study focuses on the scientific analysis of the anatomical and morphological (internal and external) structure of aphids, as well as their role in the development and transmission of plant diseases.

The anatomical and morphological structure of insects represents a scientific field that studies the internal organization and external form of their bodies, emerging from the integration of anatomy and morphology.The external structure of insects is primarily composed of an exoskeleton, which provides mechanical strength, protection against environmental factors, and facilitates movement[1]. The main component of the exoskeleton is the cuticle, a complex polymer layer rich in chitin.The outer body covering of insects is directly connected to internal muscles, allowing the exoskeleton to function as an effective support and locomotor system. In this regard, insects fundamentally differ from vertebrates, which possess an internal skeletal structure.The insect body is highly mobile and consists of multiple segments. During evolutionary development, the original segmentation (metamerism) has been partially reduced, resulting in the differentiation of the body into three main regions: the head, thorax, and abdomen [2].

Morphological and Anatomical Characteristics of Aphids. The insect body is divided into three main regions: the head, thorax, and abdomen. The head typically consists of 5–6 segments, the thorax comprises 3 segments, and the abdomen may include up to 11 segments. Thus, theoretically, the total number of segments in an insect body can reach approximately 19. However, during evolutionary development, the number of segments has been reduced due to processes such as segment fusion and

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reduction. In particular, some segments have become functionally integrated or partially underdeveloped, leading to a decrease in their total number. As a result, in most insects, the number of segments does not exceed 14, and in some species, it is even lower. The rigid exoskeleton of insects provides several advantages compared to the internal skeleton of vertebrates. It offers effective protection against environmental influences and ensures high mechanical strength. Studies indicate that the structural strength of the insect body may be several times greater than that of vertebrates. In addition to protecting internal organs, the cuticle reduces water loss through evaporation and serves as an attachment site for internal muscles. The specific structural features of the integument enable the insect to bend different parts of its body and move its appendages through muscular activity. The larger portions of the integument function as an exoskeleton, serving as attachment sites for all locomotor muscles and providing mechanical support and protection. The insect body is highly mobile and composed of sequentially arranged segments [3]. During evolutionary development, the original segmentation pattern, known as metamerism, has been partially reduced, resulting in the differentiation of the body into three main regions: the head, thorax, and abdomen.

Figure 1. Detailed anatomical organization of the aphid, illustrating the structural arrangement of key morphological components.

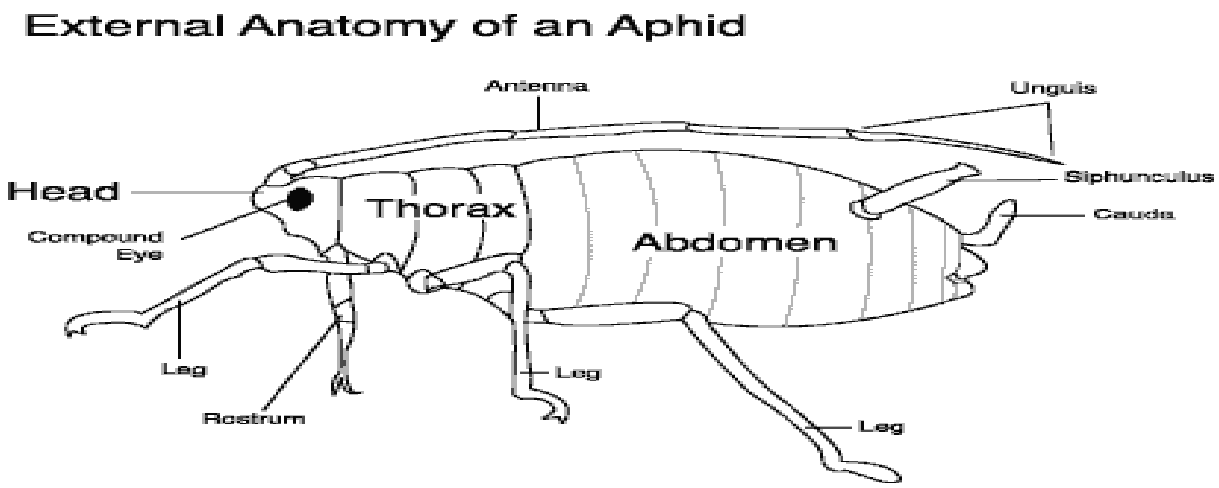

Figure 2. Structural organization and arrangement of the aphid body parts.

Figure 2 demonstrates the distribution of aphids on the young plant shoot, highlighting their typical feeding sites

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Figure 2. Distribution of aphids on the vegetative parts of the plant.

Aphids (family Aphididae) represent a diverse group of insects, with more than 4,000 species identified worldwide. Most species are considered significant pests, as they feed on plant sap and nutrients, thereby negatively affecting plant growth and development. Aphids are also recognized as important biological vectors that contribute to the spread of plant diseases, disrupting normal physiological processes in host plants.Various control methods are employed to manage aphid populations, including chemical, biological, and physical (electrophysical) approaches, each with its own advantages and limitations. Aphids (plant lice) are small insects, typically not exceeding 6 mm in length, and are commonly green or brown in color. They are characterized by a rapid reproduction rate, and in the absence of effective control measures, they can quickly spread and cause significant damage to plants, including agricultural crops [4].

Aphids are commonly found on various plant parts, including leaves, stems, and roots. They pose a serious threat particularly to fruit trees (such as apple), ornamental plants, and vegetable crops. Their feeding apparatus consists of a specialized piercing-sucking mouthpart (proboscis), which is highly adapted for extracting plant sap. By penetrating the leaf surface with this structure, aphids feed on plant fluids, disrupting nutrient transport and physiological processes. As a result, photosynthetic activity decreases, and in severe cases, the plant may wilt and eventually die. Aphids, as one of the major agricultural pests, cause significant economic damage to crop production. Their rapid population growth disrupts photosynthetic processes, facilitates the transmission of viral diseases, and ultimately reduces crop yield [5].

Materials and Methods of the Study. Conventional control methods, particularly the use of chemical insecticides, often pose serious risks to environmental safety and human health. Therefore, there is an increasing need to develop alternative, sustainable, and environmentally friendly pest control strategies. In this context, ultraviolet (UV) radiation-based treatment has recently emerged as an innovative and promising approach. This method is

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particularly relevant for controlling small yet highly destructive pests such as aphids. Aphids feed on plant sap, thereby disrupting physiological processes and, in severe cases, causing plant death. Consequently, replacing conventional chemical approaches with eco-friendly technologies represents an important scientific and practical challenge.

Ultraviolet radiation is classified into three main regions: UV-C (100–280 nm), UV-B (280–315 nm), and UV-A (315–400 nm). UV-C radiation has the shortest wavelength and exhibits strong bactericidal properties, although it is almost completely absorbed by the Earth's atmosphere under natural conditions. UV-B radiation has significant biological effects, while UV-A radiation penetrates deeper into biological tissues. UV radiation, particularly in the UV-C range, has proven to be effective against aphids. It induces structural damage to insect cells, including disruption of cell membranes and DNA molecules, thereby inhibiting their growth and reproduction. Furthermore, UV-C radiation affects the nervous system of insects, reducing their visual and orientation capabilities, which ultimately disrupts their normal behavior and contributes to population decline [6].

Figure 3 illustrates the spectral distribution of ultraviolet radiation as a function of wavelength.

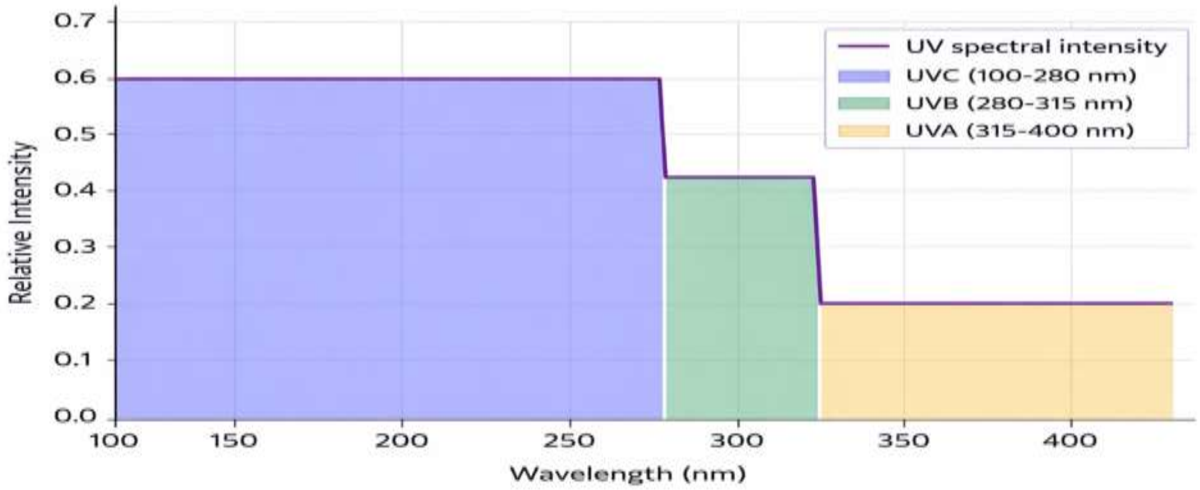

Figure 3. Spectral distribution of ultraviolet radiation according to wavelength

Ultraviolet radiation can induce excitation or stress responses in insects, causing them to abandon their habitat and exhibit irregular movement patterns. UV radiation exerts complex effects on various organs and physiological systems of aphids.

Aphids typically inhabit the lower parts of plants, where they feed and reproduce. UV radiation negatively affects their visual organs, particularly highly sensitive photoreceptors, leading to impaired vision. As a result, their feeding behavior and orientation are disrupted, which may ultimately lead to

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mortality. The external covering of aphids, known as the exoskeleton, serves as a protective barrier. UV-B and UV-C radiation can degrade structural biomolecules within this layer, weakening its protective function. This process increases water loss and disrupts physiological stability.

Furthermore, UV radiation affects the insect nervous system, reducing sensitivity and impairing their ability to respond to environmental stimuli. Consequently, their normal biological activity is significantly disrupted.

Figure 4 illustrates the feeding process of aphids on plant tissues.

Figure 4. Feeding behavior of aphids on plant sap

The respiratory system of insects is based on a tracheal system, through which oxygen is delivered directly to tissues without the involvement of blood circulation. Oxygen is transported via a network of tracheal tubes distributed throughout the body. This system plays a crucial role in gas exchange by supplying oxygen to tissues and removing carbon dioxide from the organism. Each tracheal tube is connected to the external environment through small openings called spiracles. Such a respiratory mechanism ensures efficient metabolic functioning and supports the biological activity of the insect.

Aphids, as one of the major plant pests, cause significant damage to agricultural crops. Their rapid reproduction disrupts photosynthetic processes, facilitates the spread of viral diseases, and leads to a reduction in crop yield. Conventional control methods, particularly chemical treatments, often pose environmental and health risks. Therefore, there is an increasing demand for sustainable, effective, and environmentally friendly alternative approaches to pest management. In this context, ultraviolet (UV) radiation-based treatment has attracted considerable attention in recent years as an innovative and promising technology.

Ultraviolet (UV) radiation treatment is increasingly recognized in scientific research as an environmentally safe and

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effective method. Therefore, the implementation of this technology in practical applications can serve as a promising solution to existing challenges in agriculture. The ultraviolet spectrum is divided into three main regions: UV-C (100–280 nm), UV-B (280–315 nm), and UV-A (315–400 nm). UV-C radiation has the shortest wavelength and exhibits strong bactericidal properties; however, it is almost completely absorbed by the Earth's atmosphere. UV-B radiation penetrates deeper into biological tissues, plays an important role in vitamin D synthesis, but may cause burns under excessive exposure. UV-A, having the longest wavelength, penetrates deeper into the skin and contributes to pigmentation processes [6].

Among these, UV-C radiation is particularly effective in controlling aphid populations. However, practical application of this method requires careful consideration of radiation dose, exposure duration, and safety measures. UV-C and UV-B radiation negatively affect the cellular structure of insects. These radiations damage cell membranes and DNA, thereby inhibiting insect growth and reproduction. In addition, they influence the insect nervous system, reducing visual perception and orientation ability, which ultimately disrupts their normal biological functions. The figure illustrates the distribution spectrum of ultraviolet (UV) radiation according to wavelength.

Ultraviolet (UV) radiation can stimulate certain insects or induce a stress response. Under such conditions, insects may leave their original location and exhibit altered behavioral patterns. These radiations affect multiple organs and systems of aphids, primarily impacting both their external and internal structures. UV radiation has a harmful effect on the visual organs of insects (particularly highly sensitive eye components), reducing their visual capacity [7]. As a result, their normal жизнедеятельность is disrupted, leading to reduced feeding activity and eventual death. The external covering (exoskeleton) of aphids serves as a protective mechanism; however, UV radiation, particularly UV-B and UV-C, can damage this structure. These rays degrade collagen and other molecular components in the insect cuticle, weakening their physiological and protective functions. Consequently, this process leads to excessive water loss in insects.

Figure 5. Spectrum distribution of ultraviolet radiation by wavelength

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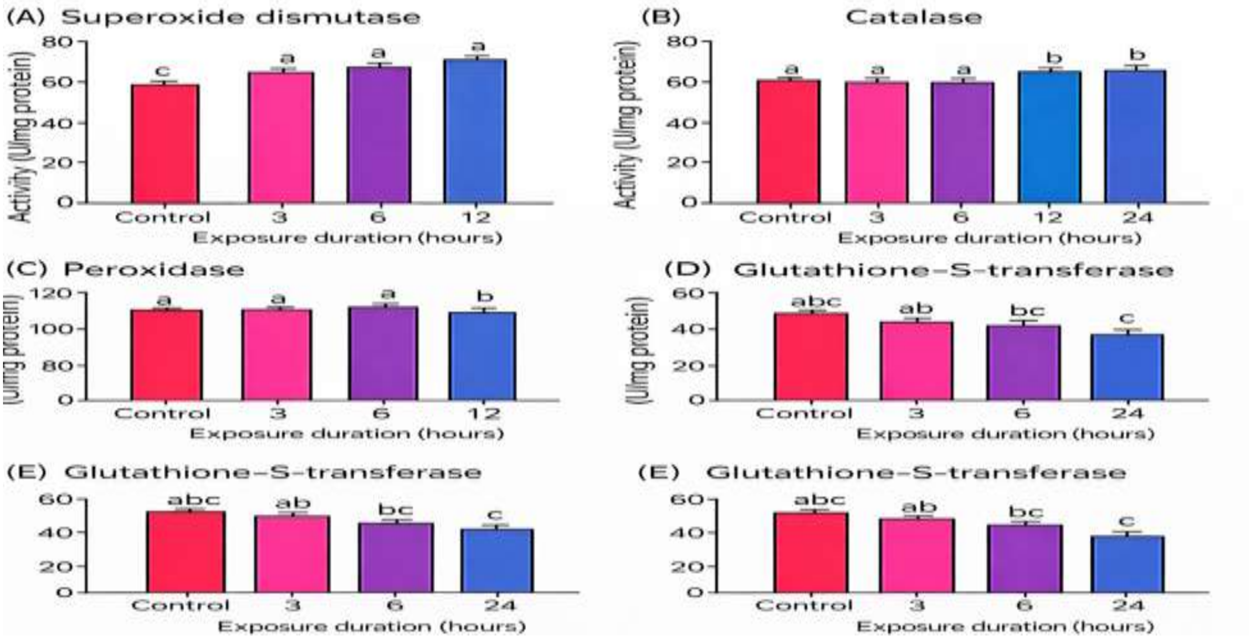

Figure 5. Dynamics of changes in the activity of superoxide dismutase, catalase, peroxidase, and glutathione- S-transferase enzymes in aphids with increasing UV-C exposure time.

With prolonged exposure, UV radiation can also damage the nervous system of aphids, reducing their sensitivity and weakening their ability to respond to environmental stimuli. The damaging effects of ultraviolet radiation on the internal organs of insects can be explained as follows. Although aphids are not directly affected in their digestive organs by UV radiation, prolonged external exposure disrupts their physiological balance. As a result, their digestion processes slow down, inhibiting growth and development.

In particular, UV-C and UV-B radiation can damage the DNA structure of insects. This leads to mutations, disruption of growth processes, inhibition of reproduction, and ultimately a reduction in the insect population [8].

CONCLUSION

In this scientific study, the anatomical and morphological structure of aphids as plant pests, their mechanisms of interaction with plant organisms, and the biological effects of ultraviolet radiation were comprehensively analyzed. The findings indicate that aphids feed on plant cell sap using specialized mouthparts, which disrupts photosynthesis, inhibits plant growth, and contributes to the transmission of viral diseases. The structural features of insects, particularly their exoskeleton (cuticle) and internal physiological systems, ensure their adaptability to environmental conditions. However, ultraviolet radiation, especially within the UV-C range, has been found to exert significant detrimental effects on insect organisms. These effects include damage to visual organs, impairment of the

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nervous system, and degradation of the protective outer layer, ultimately disrupting their. Furthermore, UV radiation affects the DNA structure of insect cells, alters enzymatic activity, and induces oxidative stress, leading to inhibited development and a reduction in population density. Based on these findings, ultraviolet radiation can be considered an environmentally friendly and promising physical method for protecting plants against insect pests.

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