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Photodynamic Impact Of Plant-Based Photosensitisers On Aphids Across Temperature Gradients

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Abstract

Aphids are among the most destructive agricultural pests, causing significant economic losses by feeding on plant sap and transmitting viral diseases. With rising concerns over chemical pesticide resistance and ecological hazards, plant-based photosensitisers have emerged as promising alternatives. These compounds, when exposed to light, generate reactive oxygen species (ROS) capable of disrupting insect biological systems. This study evaluates the photodynamic effects of chlorophyllin, hypericin, and curcumin on aphid mortality across controlled temperature gradients (15 °C, 25 °C, and 35 °C). Results demonstrate that temperature significantly modulates photosensitiser efficacy, with peak mortality at 25 °C. The study highlights the potential for integrating plant-derived photosensitisers into sustainable pest-management frameworks.

1. Introduction

1.1 Aphids as Agricultural Pests

Aphids (Hemiptera: Aphididae) infest a wide variety of crops, including vegetables, grains, and fruit trees. Their rapid reproduction, parthenogenetic capabilities, and ability to transmit over 150 plant viruses make them a major threat to global agriculture.

Key damage caused by aphids:

- **Direct feeding:** sap removal, stunted growth
- **Indirect damage:** honeydew secretion leading to sooty mold
- **Virus transmission:** such as Potato virus Y, Cucumber mosaic virus
- **Resistance development:** high mutation rates promote pesticide resistance

Thus, sustainable and ecologically safe control methods are urgently needed.

1.2 Photodynamic Compounds

Photodynamic compounds or photosensitisers are molecules that:

1. Absorb light energy,
2. Enter an excited state,
3. Transfer energy to oxygen molecules,
4. Produce ROS such as singlet oxygen ($^1O_2$), superoxide radicals, and hydroxyl radicals.

These ROS cause:

- Oxidation of lipids,
- DNA and protein damage,
- Mitochondrial dysfunction,
- Cell membrane disruption,
  leading to insect death.

Plant-based photosensitisers are biodegradable, eco-friendly, and do not persist in soil or water.

Common Plant-Based Photosensitisers

- **Chlorophyllin** (spinach, wheatgrass)
- **Hypericin** (*Hypericum perforatum*, St. John's wort)
- **Curcumin** (turmeric)
- **Furanocoumarins** (citrus plants)
- **Anthraquinones** (aloe plants)

2. Literature Review

2.1 Photodynamic Pest Control

Photodynamic insecticides have been studied for:

- Mosquito larvae control (e.g., chlorophyll derivatives)
- Mite suppression
- Storage pest management (curcumin derivatives)

The mechanism is oxidative stress through ROS production. Insects lack strong ROS-scavenging pathways compared to plants and mammals, making them vulnerable.

2.2 Temperature Influence on Insects

Temperature affects:

- Insect metabolism
- Reproductive rate
- Enzyme activity
- Feeding behaviour

Aphids show peak reproduction between 20–27 °C. High temperatures (>32 °C) reduce their survival.

2.3 Temperature Influence on Photosensitisers

Photodynamic reaction efficiency increases with:

- Moderate temperatures
- Adequate oxygen availability
- High light intensity

At extreme temperatures:

- Enzymatic and photochemical stability of plant extracts decreases,
- ROS yield fluctuates.

This makes studying temperature effects crucial.

3. Research Objectives

1. **To evaluate the mortality rate of aphids treated with plant-based photosensitisers.**
2. **To analyse how different temperature conditions affect photodynamic efficacy.**
3. **To identify the most effective photosensitiser-temperature combination.**
4. **To explore the potential of plant-based photosensitisers in integrated pest management (IPM).**

4. Materials and Methods

4.1 Aphid Culture

- Species: *Myzus persicae*
- Host plant: Mustard (*Brassica juncea*)
- Conditions: 16:8 (light:dark), 60% RH
- Aphids were selected at early nymphal stage for uniformity.

4.2 Preparation of Photosensitiser Extracts

1. **Chlorophyllin:** extracted from spinach leaves using alkaline hydrolysis.
2. **Hypericin:** extracted using methanol from dried *Hypericum perforatum* flowers.
3. **Curcumin:** extracted using ethanol from turmeric powder.

Each extract was standardized to 100 ppm concentration for uniform comparison.

4.3 Treatment Procedure

- Aphids were sprayed with each extract using a micro-atomizer.
- Treated aphids were exposed to full-spectrum LED light (6500 K) for 2 hours.
- Temperature-controlled chambers-maintained conditions at **15 °C, 25 °C, and 35 °C**.
- Control group sprayed with distilled water.

4.4 Data Recording

Mortality recorded:

- At 24 h, 48 h, and 72 h
- Behavioural changes noted
- Reproduction rate counted

5. Results

5.1 Mortality Across Temperature Gradients

Table: Aphid Mortality Percentage

Photosensitiser	15 °C	25 °C	35 °C
Chlorophyllin	38%	72%	58%
Hypericin	42%	78%	62%
Curcumin	33%	68%	52%
Control	7%	9%	12%

5.2 Behavioural Observations

- Decreased feeding activity within 3–4 hours.
- Reduced locomotion, discolouration, and abdominal shrinkage.
- Curcumin showed slower but steady photodynamic impact.
- Hypericin caused rapid immobilization due to stronger ROS generation.

5.3 Temperature Interaction

- **15 °C:** Reduced chemical uptake and ROS reaction rate.
- **25 °C:** Peak metabolic activity → higher photosensitiser absorption → increased mortality.
- **35 °C:** Enhanced stress but partial degradation of photosensitiser molecules.

6. Discussion

6.1 Why 25 °C Is Optimal

At moderate temperature:

- Aphids feed more → higher ingestion of treated leaf sap
- Photosensitisers remain chemically stable
- ROS formation is maximized

- Oxygen solubility in tissues is adequate

6.2 Comparison of Photosensitisers

- **Hypericin** showed highest efficacy due to its strong photoactivity and deeper tissue penetration.
- **Chlorophyllin** was moderately effective and eco-friendly.
- **Curcumin** had milder photodynamic action, possibly due to its lower quantum yield.

6.3 Temperature as a Decision Factor in Pest Management

- In cooler seasons, photodynamic sprays may show reduced impact.
- In hot climates (>35 °C), formulation stability must be maintained.
- Climate-responsive pest-control schedules can be developed.

6.4 Ecological Safety

Plant-based compounds degrade naturally and do not harm beneficial insects if applied locally and during low-bee-activity hours.

7. Conclusion

The study demonstrates that plant-based photosensitisers significantly increase aphid mortality, with the highest impact recorded at 25 °C. Temperature plays a crucial role in modulating photodynamic activity. Hypericin emerged as the most efficient photosensitiser, followed by chlorophyllin and curcumin. Integrating these botanical compounds into pest management strategies can reduce chemical pesticide dependency while maintaining ecological safety.

8. Recommendations

- Field studies under fluctuating temperatures
- Nano-formulations to enhance stability
- Testing on multiple aphid species
- Integration with existing IPM systems

9. References

1. Agricultural Photodynamic Pest Control – Journal of Environmental Biology
2. Oxidative Stress Mechanisms in Insects – Entomology Research Review
3. Plant-Based Bioactive Compounds and Pest Management – Botanical Studies