Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 05, Issue: 05 (SEP-OCT, 2025)
Available online at http://www.agriarticles.com

Pesticides: A Silent Enemy of Silkworm

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Sericulture is an agro-based industry that provides livelihood to millions of rural families across Asia, particularly in India and China. The productivity of sericulture depends on the health and survival of the silkworm, *Bombyx mori* L which feeds on mulberry leave alone. Currently farmers facing rise in the pest and disease problems in crops and they are adopting chemical control method to overcome this issue. These chemical control of pest and disease initially may yields good results but its deterioration effect on leaf yield as well as quality of cocoon productivity will be experienced lately. Since silkworm are highly sensitive to chemical pollutants, especially insecticides when chemically contaminated leaves fed to them it directly affects their growth, health and silk quality. Silkworm are delicate insects, even small traces of pesticides can cause larval death, stunted growth, poor cocoon formation and ultimately heavy crop loss. Mulberry plots adjacent to crops like paddy, cotton, sugarcanes, horticultural crops and vegetables, where pesticide use is intensive. However, insecticides will drift into mulberry field or contaminate irrigation water indirectly harming silkworm. Even minute residues of insecticides on mulberry leaves can prove fatal to silkworms or result in chronic damage to their growth and development.

Pathways of Insecticide Exposure

Silkworm is highly sensitive to chemical exposure, especially insecticides used in agricultural fields surrounding mulberry gardens. Silkworm is not usually targeted by insecticides, yet they are unintentionally exposed through multiple direct and indirect pathways, affecting their growth, development and cocoon quality.

1. Through Mulberry Leaves (Oral Ingestion)

- This is the most common route of exposure.
- When mulberry plants are sprayed with insecticides, residues remain on leaf surfaces
- Silkworm consumes these contaminated leaves during rearing.
- Leads to toxicity symptoms such as loss of appetite, vomiting of ingested leaves, sluggishness and mortality.

2. Airborne Drift (Inhalation & Contact)

- Insecticides sprayed in nearby agricultural fields (paddy, cotton, vegetables) drift as fine droplets or aerosols into mulberry gardens and rearing houses.
- Silkworms absorb these chemicals through spiracles (respiratory openings) or body surface contact.
- This is common in sericulture areas interspersed with other crops.

3. Contaminated Mulberry Field Soil

- Continuous application of insecticides in mulberry gardens or adjoining fields contaminates soil.
- Mulberry roots uptake these chemicals, which are then translocated into leaves consumed by silkworms.
- Chronic exposure can occur even without fresh spraying.

4. Water Contamination

- Irrigation water mixed with pesticide residues enters mulberry gardens.
- Residues accumulate on leaf surfaces or within plant tissues.
- Washing of sprayers in nearby ponds/rivers also contaminates water used for irrigation.

5. Handling by Farmers (Indirect Transfer)

- Farmers or laborers handling mulberry leaves after spraying other crops may transfer residues via their hands, clothes, or equipment.
- Contaminated leaves fed unknowingly to silkworms cause sudden mortality.

6. Residues in Rearing House

- Fumigation of rearing houses with chemicals or use of insecticides against pests (ants, cockroaches, uzi fly) leaves harmful residues.
- Silkworms get exposed through body contact, respiration, or contaminated feed placed in such rooms.

7. Volatilization and Vapors

- Some insecticides are volatile and release harmful vapors into the air.
- Vapors enter rearing houses and affect silkworms even without direct spraying.

8. Contaminated Manures and Compost

- Use of farmyard manure, compost, or organic matter contaminated with pesticide residues introduces chemicals into mulberry gardens.
- Residues persist in leaves and indirectly reach silkworms.

Effect on Silkworm Growth and Development

The most striking impact of insecticides is seen on larval health. When silkworm ingest contaminated leaves, acute poisoning may occur, leading to restlessness, vomiting, tremors, paralysis and sudden death. However, more often they suffer from sub-lethal effects that are not immediately visible but gradually impair their growth and productivity.

Insecticides reduce the activity of digestive enzymes such as amylase, protease and lipase, which are critical for nutrient absorption. Poor digestion and assimilation cause larvae to remain undersized and weak. Growth becomes retarded and the normal larval period is prolonged. Molting, a vital developmental process regulated by hormones, is also disturbed. Larvae either delay molting or shed their cuticle incompletely, resulting in uneven batches that are difficult to manage. The silk gland, which is the organ of economic importance in silkworms, is highly sensitive to chemical stress. Exposure to insecticides leads to atrophy of the silk gland, reduced fibroin and sericin synthesis and lowered protein content. Consequently, cocoons formed by affected larvae are small, flimsy and inferior in quality. The cocoon shell ratio decreases and the silk filaments obtained during reeling are weak, broken, and less marketable.

Reproductive and Intergenerational Effect on Silkworm

The adverse impact of insecticides does not stop at larval development. Pupae and adults emerging from contaminated larvae are weaker and less productive. Female moths lay fewer egg and egg viability decreases significantly. This affects seed production and creates long-term challenges for sustaining the next generation of silkworm. In some cases, exposure leads to sterility or abnormal embryonic development.

Mechanism of Toxicity

The harmful effects of insecticides arise from their physiological and biochemical modes of action. Organophosphates and carbamates inhibit acetylcholinesterase, causing nervous system disturbances that affect feeding and movement. Synthetic pyrethroids cause hyperexcitation of nerve cells, leading to tremors and paralysis. Some insecticides act as endocrine disruptors, interfering with the secretion of ecdysone and juvenile hormones required for molting and metamorphosis. In addition, chemical residues generate oxidative stress, damaging silk gland cells and reducing silk protein synthesis.

Symptoms of pesticide affected silkworm:

1. Egg Stage
- Poor or no hatching of eggs
- Embryonic death inside eggs
- Discoloration of eggs
- Weak or deformed larvae emerging

2. Larval Stage (Most Sensitive Stage)

External Symptoms
- Sudden larval mortality (especially in younger instars)
- Restlessness and continuous crawling
- Vomiting of gut juice
- Loss of appetite (stoppage of feeding on mulberry leaves)
- Shrinkage or wrinkling of body
- Loss of normal sheen and luster of body skin
- Blackening or spotting on cuticle (due to poisoning)
- Paralysis or sluggishness before death

Internal / Physiological Symptoms
- Poor digestion and reduced assimilation of mulberry leaves
- Abnormal swelling or bloating of gut
- Damage to silk glands (atrophy, reduced size)
- Inhibited hemolymph circulation and clotting
- Nervous system disorder leading to tremors and jerky movements

3. Pupal Stage
- Failure of larvae to spin proper cocoons
- Incomplete cocoon formation with loose or thin layers of silk
- Pupae inside cocoons becoming black or shriveled
- High pupal mortality
- Failure in metamorphosis (larvae unable to pupate properly)

4. Adult Moth Stage
- Deformed moths emerging from cocoons
- Weakness and inability to mate
- Reduced fecundity with low egg-laying capacity
- Sterility in male or female moths

5. Cocoon and Silk Quality Symptoms
- Reduced cocoon weight and shell ratio
- Flimsy, loose, or thin cocoons
- Stained, spotted, or fragile cocoons
- Poor reeling performance with frequent thread breaks
- Lower silk yield and inferior silk quality

Economic and Environmental Consequences

Insecticide poisoning of silkworms has direct economic consequences for farmers. Entire crops of silkworm may be lost within hours of contamination, leading to severe financial losses. Even when mortality is not immediate, reduced cocoon yield and poor silk quality lower the income of farmers. Moreover, frequent exposure to insecticide drift makes sericulture unsustainable in intensively cultivated agricultural regions.

Management of insecticide effect

To minimize insecticide hazards, several strategies need to be adopted. Farmers must avoid the use of toxic chemicals in mulberry gardens and instead promote biopesticides, neem formulations and cultural pest management practices. Buffer zones should be established between mulberry plantations and heavily sprayed crops. Training and awareness programs are essential to educate farmers about the timing of pesticide applications, safe leaf collections and proper storage before feeding to silkworms. At a policy level, regulatory restrictions on the use of highly toxic insecticides in sericulture regions are crucial.:

1. Spatial and Temporal Separation

- Avoid spraying insecticides near mulberry gardens, especially during silkworm rearing seasons.
- Schedule spraying during non-rearing periods or when silkworms are at less vulnerable stages.
- Maintain buffer zones between mulberry plantations and other agricultural fields where pesticides are used.

2. Safe Application Practices

- Spray insecticides early in the morning or late evening to reduce drift.
- Use low-drift nozzles and avoid spraying during windy conditions.
- Adopt spot-spraying instead of blanket spraying to minimize chemical exposure.

3. Use of Safer Alternatives

- Promote biopesticides (e.g., neem-based formulations, Bacillus thuringiensis, Trichoderma) instead of synthetic chemicals.
- Encourage Integrated Pest Management (IPM) practices that rely on biological control, cultural practices, and resistant varieties.

4. Mulberry Garden Protection

- Construct live barriers (hedges, tall border trees like Eucalyptus, Casuarina, or Glyricidia) around mulberry fields to reduce pesticide drift.
- Provide physical barriers like polythene sheets or nets during nearby spraying operations.
- If insecticides must be used in adjacent fields, prefer less-toxic and fast-degrading formulations.
- Schedule spraying at least 25–30 days before leaf harvest for silkworm feeding.

5. Rearing House Protection

- Ensure silkworm rearing houses are located away from crop fields that frequently receive chemical sprays.
- Keep windows and ventilators covered with fine mesh during spraying in nearby fields.
- Spray water on thatched/roof surfaces to neutralize drift residues before ventilation.

6. Soil and Leaf Safety Measures

- Wash mulberry leaves thoroughly with clean water before feeding silkworms if pesticide contamination is suspected.
- Avoid feeding leaves collected immediately after spraying; allow a safety interval (generally 10–15 days depending on chemical).

7. Safe Irrigation Practices

- Use clean water for irrigation.
- Prevent entry of pesticide-contaminated runoff water from nearby agricultural fields.
- Avoid washing sprayers or pesticide containers in irrigation channels or tanks used for mulberry.

8. Awareness and Training

- Educate farmers about the high sensitivity of silkworms to pesticides.
- Promote awareness campaigns on pesticide-free zones around sericulture areas.
- Train farmers on the correct use of bio-rational methods for pest management in companion crops.

9. Policy and Community Action

- Establish “Silkworm Protection Zones” with strict regulations against insecticide spraying.
- Coordinate with neighboring farmers to follow pesticide application schedules that avoid harm to silkworms.

- Government agencies should support sericulturists with subsidies for IPM kits and biofertilizers.

Conclusion

Insecticide exposure represents one of the most critical challenges to sericulture, given the extreme sensitivity of silkworm to chemical residues. The disruption spans across all developmental stages-from larval mortality, retarded growth and hormonal imbalance to reduced silk gland activity, poor cocoon spinning and defective pupation. Beyond biological damage, the economic consequences are severe, as farmers face reduced cocoon yield, inferior silk quality and potential crop losses. The persistence of these challenges threatens the socio-economic sustainability of sericulture, which provides livelihood to millions of rural families. Therefore, ensuring the long-term prosperity of the silk industry requires a multi-pronged approach: strict regulation of pesticide use in sericulture areas, promotion of eco-friendly and biological pest management strategies, establishment of pesticide-free buffer zones and continuous farmer training. Protecting silkworm health is not only essential for maintaining productivity but also for preserving the cultural and economic significance of sericulture.

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