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Basanagouda Jekinakatti
Department of Sericulture, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Doreswamy C
College of Agriculture, Chamarajanagara, Karnataka, India

Ashrith S
Department of Sericulture, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Sushmitha C
Department of Sericulture, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Kaveri Aramani
Department of Sericulture, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Tejaswini AS
Department of Sericulture, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Corresponding Author:
Basanagouda Jekinakatti
Department of Sericulture, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Impact of feeding pesticides treated mulberry leaves on larval parameters of silkworm hybrid FC2

Basanagouda Jekinakatti, Doreswamy C, Ashrith S, Sushmitha C, Kaveri Aramani and Tejaswini AS

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Abstract
A bioassay was undertaken to evaluate the impact of pesticide-treated mulberry leaves on the larval parameters of silkworm hybrid FC2. The pesticides used for efficacy study against mulberry pests were selected based on recommended label doses and sprayed onto the plants. Leaves were harvested and fed to silkworms at intervals of 5, 10, 15 and 20 days after spraying (DAS) to assess their residual toxicity. The study revealed that Azadirachtin 1% (2 mL/L) and Chlorfenapyr 10 SC (1.5 mL/L) exhibited the highest levels of toxicity with larval mortality rates of 100% and 24.75%, respectively at 10 DAS. Toxicity from both chemicals declined significantly at 15 DAS. In contrast, Orgomite, a botanical pesticide (2.5 mL/L), demonstrated minimal toxicity causing only 7.50% mortality at 10 DAS. Wettable Sulphur 80 WP (2 g/L) and Era Safeguard (2.5 mL/L) were also relatively safer with mortality rates of 8.58% and 18.50%, respectively at the same interval. Additionally, the longest fifth instar larval duration was observed in the Chlorfenapyr treated group while the shortest was seen in the water sprayed control and Orgomite treated groups. Corresponding reductions in larval weight and effective rate of rearing were observed in accordance with toxicity levels. The findings indicate that Orgomite was the safest among the tested products, followed by Wettable Sulphur and Era Safeguard even within 10 days of application. Chlorfenapyr 10 SC, while effective required a minimum safety interval of 15 days to minimize harm to silkworms. Therefore, Orgomite and Chlorfenapyr 10 SC can be recommended for effective pest management in mulberry with respective post-spray safety periods of 10 and 15 days for safe silkworm rearing.

Keywords: Pesticides, mulberry, silkworm, toxicity

Introduction

Sericulture, the art and science of rearing silkworms for silk production. It is a vital agro-based industry that supports the livelihoods of 7.85 million, especially in rural areas (Raju *et al.*, 2020) [8]. Among the various commercially exploited silkworm species, mulberry silkworm (*Bombyx mori*) is the most prominent, alongside non-mulberry species such as *Antheraea mylitta*, *Antheraea assamensis*, and *Philosamia ricini* cultivated in specific ecological niches across India and other countries.

The success of sericulture largely depends on the health and productivity of silkworms which are highly sensitive to environmental changes and chemical exposure. One of the growing concerns in modern sericulture is the adverse impact of insecticides used in nearby agricultural fields. Although intended to control pests in mulberry cultivation. Many broad-spectrum insecticides inadvertently affect silkworms due to their non-target toxicity. These chemicals can enter the silkworm's system directly through contaminated mulberry leaves or indirectly via residues in the environment.

Toxic exposure often results in reduced larval viability, impaired cocoon formation, disrupted silk gland development and in severe cases, mass larval mortality. Organophosphates, synthetic pyrethroids and neonicotinoids are among the common groups of insecticides known to exert harmful effects on silkworms. As sericulture is intimately linked with agriculture, this overlap poses significant challenges in ensuring safe and sustainable silkworm rearing practices.

The application of insecticides in mulberry cultivation must be highly selective as indiscriminate use can severely affect silkworm health and productivity. Studies have shown that pesticide-related impacts account for over 1.4% of yield loss in sericulture (Sik *et al.*,

1976) [12]. Understanding the mechanisms of insecticide toxicity is essential for assessing their direct impact on the larval parameters of silkworms including growth rate, larval duration, weight gain and survivability. Exposure to sub-lethal or lethal doses of insecticides either through contaminated mulberry leaves or through residues can severely impair larval development. Therefore, this article examines the impact of insecticides used for controlling mulberry pests on various larval parameters of the silkworm.

Materials and Methods

An experiment was conducted during 2022-23 at the College of Agriculture, KVK, Chamarajanagara, in a well-maintained V-1 mulberry garden to assess the impact of feeding silkworms with insecticide-treated mulberry leaves. Commercial bivoltine silkworm hybrid FC2 was used and rearing was carried out by adhering to the standard practices recommended by Dandin and Giridhar (2014) [2]. Silkworm eggs were sourced from the NSSO, Central Silk Board (CSB), Bangalore. For uniform and maximum hatching black boxing was performed for 48 hours at the pinhead stage, followed by exposure to diffused light. Post-hatching, the larvae were carefully transferred from the egg sheets to paraffin paper-lined rearing trays.

The young larvae were fed finely chopped, fresh and tender V-1 mulberry leaves until they reached the fourth instar. At the start of the fourth instar, after an initial 30-minute feeding period 50 larvae were randomly selected and transferred to individually labeled experimental trays for each treatment. During the fifth instar, the larvae were offered mulberry leaves treated with different insecticides: Chlorfenapyr 10 SC (1.5 mL/L), Wettable Sulphur 80 WP (2 g/L), Orgomite (2.5 mL/L), Era Safeguard (2.5 mL/L), and Azadirachtin 1% (2 mL/L) administered at 5, 10, 15 and 20 days after spraying (DAS). The experimental layout followed a Randomized Complete Block Design (RCBD) consisting of seven treatments replicated four times.

Results and Discussion

Larval mortality

Silkworm larvae were fed mulberry leaves treated with various insecticides to assess mortality. The results showed a significant difference in mortality rates among the treatments after insecticide application. Larval mortality was observed to be highest across all silkworm batches at 5 days after spraying (DAS) and it gradually declined as the interval after spraying increased. Among the five pesticides tested at 10 DAS, the highest mortality was recorded in silkworms fed with leaves treated with Azadirachtin 1% (100%), followed by Chlorfenapyr 10 SC (24.75%) and Era Safeguard (18.50%). The lowest mortality was noted in the Orgomite-treated batch (7.50%) at 10 days after spraying, followed closely by Wettable Sulphur 80 WP (8.58%). However, by 15 and 20 days after spraying, no significant differences in larval mortality were observed among the treatment groups (Table 1).

The high mortality observed in the Azadirachtin-treated group could be attributed to the presence of biologically active compounds with strong antifeedant properties, as suggested by Rao and Raja (2016) [9]. According to Vasanth *et al.* (2025) [13], mortality rates in silkworms increased sharply from 3.76% to 99.11% as Chlorfenapyr concentration rose from 0.01 to 10 ppm with LC_{50} values ranging between 0.3 and 0.4 ppm (48.88% and 53.96%). Chlorfenapyr, a pyrrole-derived insecticide, disrupts insect respiration by uncoupling oxidative phosphorylation. This disruption hampers energy production, ultimately causing paralysis and death due to the inability to perform essential physiological functions (Yang *et al.*, 2019) [14]. This mechanism may explain the continued larval mortality observed even up to 15 days after spraying (DAS). Similarly, Narayanawamy *et al.* (2017) [6] found that silkworms fed on mulberry leaves treated with 4% NSKE on the 22nd day post-application exhibited minimal larval mortality (2.11%) without adversely affecting the economic traits of the PM × CSR2 hybrid. Supporting this, Kumar *et al.* (2019) [3] reported 100% larval mortality at 10 DAS in silkworms fed with mulberry leaves treated with Azadirachtin 0.03 EC at a concentration of 2.0 ml/l.

Fifth instar larval weight

At 10 days after spraying (DAS), silkworms fed with mulberry leaves treated with Orgomite showed the highest larval weight of 3.03 g, followed by those fed with leaves sprayed with Wettable Sulphur 80 WP (2.96 g) and Era Safeguard (2.90 g). By 15 DAS, Chlorfenapyr 10 SC and Azadirachtin 1% appeared relatively safer, with larval weights of 2.95 g and 2.98 g, respectively. However, no significant differences were observed in the fifth instar larval weights between 15 and 20 DAS across treatments (Table 2). The reduction in larval weight may be attributed to several factors, including diminished nutrient absorption from treated leaves, increased metabolic activity to counter pesticide stress, reduced digestive enzyme activity and loss of digestive fluids through vomiting, diarrhea, or starvation. Specifically, the weight reduction in Azadirachtin-treated groups could be due to its antifeedant effects. Supporting this, Maria *et al.* (2000) [5] noted that certain insecticides can reduce larval weight when silkworms consume treated mulberry leaves.

These findings are consistent with those of Narayanaswamy *et al.* (2017) [6] who observed that silkworms fed on mulberry leaves treated with NSKE showed significantly lower larval weights of 2.55 g, 2.57 g, 2.59 g and 2.62 g on the 16th, 17th, 18th and 19th days after spraying, respectively. Similarly, Patnaik *et al.* (2011) [7] reported a reduction in larval weight to 2.49 g per larva when fed on mulberry leaves treated with Thiamethoxam (0.015%) compared to 2.51 g in the untreated control group. Kumutha *et al.* (2013) [4] also noted that higher concentrations of the pesticide Vijay Neem had a more pronounced negative effect on larval weight than Dichlorvos.

Fifth instar larval duration

Across all spraying intervals from 5 to 20 days after spraying (DAS), the longest larval duration was observed in silkworms fed with mulberry leaves treated with Chlorfenapyr 10 SC at 1.5 mL/L, followed by those treated with Era Safeguard at 2.5 mL/L. The shortest larval duration was recorded in the water-sprayed control group, followed by the Orgomite treatment at 2.5 mL/L. At 10 DAS, the highest fifth instar larval duration was 230.76 hours in the Chlorfenapyr-treated group, while the shortest larval duration of 221.88 hours was observed in the Orgomite-treated group. At 15 and 20 DAS, no significant differences were found in larval duration across all treatments (Table 3). However, larval duration was observed to be longest at 5

DAS and shortest at 20 DAS, indicating that extended intervals after pesticide application representing longer safety periods promote healthier and more efficient larval development.

Santorum *et al.* (2019) [10] observed prolonged larval duration in silkworms fed on mulberry leaves treated with Novaluron, attributing the delay to disruption in the hormonal balance required for metamorphosis. Similarly, Kumar *et al.* (2019) [3] reported extended larval durations when silkworms consumed leaves sprayed with Azadirachtin 0.03% EC at 2 mL/L, recording durations of 215.33 hours at 15 DAS, 205.56 hours at 20 DAS, 190.00 hours at 25 DAS and 184.00 hours at 30 DAS. Yeshika *et al.* (2019) [15] found that Azadirachtin 1% at 1 mL/L resulted in the longest fifth instar duration at 10 DAS (221.83 hours), followed by 20 DAS (220 hours) and 40 DAS (217 hours). Additionally, Narayanaswamy *et al.* (2017) [6] also noted an increase in fifth instar larval duration in silkworms fed with mulberry leaves treated with 4% NSKE.

The effective rate of rearing (ERR)

Among all pesticide treatments evaluated between 5 and 10 days after spraying (DAS), the highest effective rate of rearing (ERR) was recorded in silkworms fed with mulberry leaves treated with Orgomite (91.48%), followed by Wettable Sulphur 80 WP (90.76%). The lowest ERR was observed in the Chlorfenapyr 10 SC-treated group (73.48%), followed by Era Safeguard (79.76%). At 15 DAS, the maximum ERR of 92.83% was again noted in the Orgomite-treated batch, while the minimum ERR (89.53%) was recorded in silkworms fed with Chlorfenapyr-treated leaves. At 15 DAS, ERR values of 92.62%, 92.57%, and 90.49% were observed in batches treated with Wettable Sulphur 80 WP, Azadirachtin 1% and Era Safeguard, respectively. By 20 DAS, no significant differences were found among the ERR values across all treatments (Table 4). However, an overall improvement in ERR was observed with the extension of the post-spray safety interval indicating that longer safety periods positively influence rearing outcomes regardless of the pesticide used.

The variation in the effective rate of rearing (ERR) among different treatments could be attributed to silkworm mortality caused by residual insecticides present on the treated mulberry leaves. Supporting this, Bandyopadhyay *et al.* (2013) [1] reported an ERR of 93% when silkworms were fed with mulberry leaves treated with 1% Neem oil at 15 days after spraying. Similarly, Sharath *et al.* (2022) observed a 94.66% ERR in silkworms fed with mulberry leaves sprayed with 1% Azadirachtin at 2 mL/L, administered 16 days after spraying. Vasanth *et al.*, (2025) [13] reported decreased effective rate of rearing (ERR) steadily with increasing concentrations of chlorfenapyr, dropping from 96.24% in the control group to just 0.89% at 10 ppm.

Table 1: Effect of feeding pesticide treated mulberry leaves on larval mortality

Treatment details	Larval mortality (%)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10% SC @ 1.5 mL/L	74.25	24.75	8.25	2.34
T_2: Wettable Sulphur 80 WP @ 2 g/L	31.75	8.58	4.05	0.25
T_3: Orgomite @ 2.5 mL/L	17.50	7.50	3.67	0.00
T_4: Era Safeguard @ 2.5 mL/L	66.50	18.50	7.83	1.88
T_5: Azadirachtin 1% @ 2 mL/L	100.00	100.00	5.92	0.83
T_6: Water spray	0.00	0.00	0.00	0.00
T_7: Untreated control	0.00	0.00	0.00	0.00
F-test	**	**	NS	NS
S.Em±	15.27	12.96	2.07	0.66
CD @ 5%	45.38	38.52	-	-

*Significant at 5%; ** Significant at 1%; DAS-Days after spraying.

Table 2: Effect of feeding pesticide treated mulberry leaves on fifth instar larval weight

Treatment details	Fifth instar larval weight (g/larva)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10% SC @ 1.5 mL/L	2.81	2.91	2.95	2.97
T_2: Wettable Sulphur 80 WP @ 2 g/L	2.90	2.96	3.01	3.06
T_3: Orgomite @ 2.5 mL/L	2.91	3.03	3.06	3.09
T_4: Era Safeguard @ 2.5 mL/L	2.83	2.90	2.96	3.00
T_5: Azadirachtin 1% @ 2 mL/L	-	-	2.98	3.04
T_6: Water spray	3.05	3.06	3.07	3.09
T_7: Untreated control	3.13	3.13	3.13	3.13
F-test	**	**	NS	NS
S.Em±	0.06	0.08	0.06	0.05
CD @ 5%	0.17	0.23	-	-

*Significant at 5%; ** Significant at 1%; NS-Non significant; DAS-Days after spraying.

Table 3: Effect of feeding pesticide treated mulberry leaves on fifth instar larval duration

Treatment details	Fifth instar larval duration (h)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10% SC @ 1.5 mL/L	240.96	230.76	225.78	223.56
T_2: Wettable Sulphur 80 WP @ 2 g/L	225.36	224.76	222.00	221.16
T_3: Orgomite @ 2.5 mL/L	223.02	221.88	221.22	220.50
T_4: Era Safeguard @ 2.5 mL/L	237.24	227.40	224.58	223.32
T_5: Azadirachtin 1% @ 2 mL/L	-	-	222.96	221.88
T_6: Water spray	220.68	220.08	220.20	219.12
T_7: Untreated control	219.12	219.12	219.12	219.12
F-test	**	**	NS	NS
S.Em±	5.09	3.34	5.15	3.52
CD @ 5%	15.11	9.93	-	-

*Significant at 5%; ** Significant at 1%; NS-Non significant; DAS-Days after spraying.

Table 4: Effect of feeding pesticide treated mulberry leaves on effective rate of rearing (ERR)

Treatment details	Effective rate of rearing (ERR) (%)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10% SC @ 1.5 mL/L	24.35	73.48	89.53	96.43
T_2: Wettable Sulphur 80 WP @ 2 g/L	65.29	90.76	92.62	97.93
T_3: Orgomite @ 2.5 mL/L	79.92	91.48	92.83	98.92
T_4: Era Safeguard @ 2.5 mL/L	31.66	79.76	90.49	96.84
T_5: Azadirachtin 1% @ 2 mL/L	-	-	92.57	97.63
T_6: Water spray	100.00	100.00	100.00	100.00
T_7: Untreated control	100.00	100.00	100.00	100.00
F-test	**	**	*	NS
S.Em±	15.15	12.81	2.31	1.04
CD @ 5%	45.02	38.07	6.87	-

*Significant at 5%; ** Significant at 1%; DAS-Days after spraying.

Conclusion

The study demonstrates that Orgomite is the safest pesticide for silkworm rearing even within 10 days of application, followed by Wettable Sulphur and Era Safeguard. Chlorfenapyr 10 SC, though effective requires a minimum 15 day safety interval to avoid harming silkworms. Thus, Orgomite and Chlorfenapyr can be effectively used in mulberry pest management with proper post-spray intervals to ensure silkworm safety.

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