Assessing the Impact of Abamectin and Diafenthiuronon Silkworm Larval Growth and Survival

Abstract:

An experiment to evaluate abamectin 1.9% EC and diafenthiuran 50% WP for safety period on mulberry silkworm, *Bombyx mori* L. was conducted (Jan-Feb and Mar-April 2023) where in the pesticides were sprayed on mulberry at different durations, after spraywere fed to the silkworms from third instar onwards. There was no mortality (0.00%) of silkworm observed in both the treatments during two seasons and the larval progression 100 % during third, fourth and fifth instars. The total larval duration was found shortest when the silkworms were fed with mulberry leaves harvested from the plots sprayed with abamectin 1.9% EC @ 0.75ml/lit (22.30 and 23.22 days) and diafenthiuron 50% WP @ 1 g/lit (22.77 and 23.07days) at 15 and 21 DAS, respectively. The larvalweight was significantly maximumin the treatments with abamectin 1.9% EC @ 0.75 ml/lit (4.29 and 4.08 g/larvae) diafenthiuron 50% WP @ 1 g/lit (4.17 and 4.06g/ larvae), respectively at 15 and 21 DAS. The Effective Rate of Rearing (ERR %) recorded significantly highest with diafenthiuron 50% WP @ 1 g/lit (97.78 and 96.67 % at 15 and 21 DAS) and abamectin 1.9% EC @ 0.75 ml/lit(97.78 and 96.67% at 15 and 21 DAS) that was comparable with control. The molecules, diafenthiuron 50% WP @ 1 g/lit and abamectin 1.9% EC @ 0.75ml/lit were found safer to silkworms at 15 and 21 DAS in terms of survival and larvae larval growth.

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Keywords: Silkworm, larval growth, survival, abamectin, and diafenthiuron

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1.Introduction

The silkworm, *Bombyx mori* L. is a monophagous insect relying solely on mulberry leaves, which serve as a critical and indispensable source of nutrition for silkworms. The mulberry foliage plays an irreplaceable role in providing vital nutrition for silkworms, ultimately influencing the production of cocoons of remarkable quality (Mahadeva, 2011). The success and profitability of silkworm rearing is intrinsically linked to the superior quality and abundant yield of mulberry foliage. Multiple factors, such as judicious selection of varieties, meticulous agronomic practices, and the intricate interplay of both biotic and abiotic components collectively influence the overall excellence of mulberry leaves (Krishnaswami *et al.*, 1970). The luxuriant foliage of mulberry attracts the attention of numerous pests, leading to substantial damage and noteworthy losses in terms of both yield and quality. More than 300 insect and non-insect pests infesting mulberry have been well documented, each inflicting a diverse range of damages (Narasimhanna, 1988).

Use of chemicals is a crucial component of integrated pest management, aimed at keeping both insect and non-insect pests under check in mulberry plantations. Pesticides, which are synthetic agents designed to disrupt pest physiology in order to protect host plants,play a vital role in sericulture. Regrettably, the resilient silkworm species, *B. mori* L., displays limited resistance to the potent impact of insecticides, leading to a distressing annual decline of more than 30 per cent in silk production attributed to insecticide poisoning (Bing *et al.,* 2010). Exposing silkworms to insecticide residues can have profound repercussions on their life cycle, affecting essential aspects such as growth, reproduction, cocoon quality, eclosion (hatching) and fecundity (Bhosale and Kallapur 1985). Hence, it is imperative to handle pesticides with care and ensure their responsible use that would ensure safeguarding the health and well-being of the silkworms while effectively managing pests in mulberry plantations. Exploring alternative pest control measures and embracing integrated pest management practices will empower the industry to cultivate mulberry sustainably, safeguarding crop health and ecological balance in the process.

In the light of this context, a comprehensive research endeavour has been formulated with the following primary goals: to identify promising chemical compounds that can effectively replace DDVP in countering the infestation of thrips and mites. This study aims to evaluate chemicals exhibiting dual insecticidal and acaricidal properties, with a specific focus on their compatibility with silkworms and indigenous natural predators within the mulberry ecosystem.

2. Materials and methods

The experiment was laid out in a well-established V-1 mulberry garden following Randomized Complete Block Design (RCBD) with 11 treatments and three replications (Table 1). Theleaveswereharvested separately from each replication by following individual leafharvestmethod. The feeding of treated mulberry leaves was initiatedfromsecond feeding after the second moult.

Table 1: Treatment details

Sl No.	Treatments	Description
1	**T_1**	Diafenthiuron 50% WP (@ 1 g/lit) at 8 DAS
2	**T_2**	Diafenthiuron 50% WP (@ 1 g/lit) at 15 DAS
3	**T_3**	Diafenthiuron 50% WP (@ 1 g/lit) at 21 DAS
4	**T_4**	Abamectin 1.9% EC(@ 0.75ml/lit) at 8 DAS
5	**T_5**	Abamectin 1.9% EC (@ 0.75ml/lit) at 15 DAS
6	**T_6**	Abamectin 1.9% EC (@ 0.75ml/lit) at 21 DAS
7	**T_7**	Diamethoate 30% EC (@ 2 ml/lit)
8	**T_8**	Cyanopyrafen 30% EC (@ 0.5ml/lit)
9	**T_9**	Azadirachtin 1% EC (@ 1ml/lit)
10	**T_{10}**	Control (water spray)
11	**T_{11}**	Absolute control

2.1 Disinfectionofrearingroom

Thesilkwormrearinghouseandapplianceswerethoroughlycleaned,sundried and disinfected beforecommencementofrearing.Theentirerearingroomalongwith applianceswasdisinfectedbyfollowingstandardproceduresuggestedbyDandinand Giridhar(2014).

2.2 Silkwormrearing

The chawki silkworms of bivoltine double hybrid (FC1 x FC2) were sourced from a registered chawki rearing center and reared at the Department of Sericulture, College of Agriculture, UAS, GKVK, Bangalore. Ninety larvae were transferred to each experimental tray with three replications per treatment. The larvae were fed with leaves harvested at different intervals of chemical spraying. Feeding the treated leaves commenced from the second feed of the third instar onwards. Bed cleaning was performed thrice during the third instar, twice during the fourth instar (after the third moult and before the fourth moult), and once daily during the fifth instar. Lime powder was dusted on the silkworms at each moult to keep the bed dry and facilitate easy moulting. Ripe worms were handpicked from the rearing bed and mounted on bamboo chandrike for cocoon spinning. The cocoons were harvested on the fifth day after mounting.

2.3 Observationsrecorded

2.3.1 Rearing parameters

2.3.1.1 Larvalmortality (%)

Thelarvalmortalityduetodifferentchemicalswasrecorded separatelyineachreplicationfor everytreatmentandcomputedas below:

$$\text{Larval mortality (\%)} = \frac{\text{Number of dead larvae}}{\text{Total number of larvae treated}} \text{ X } 100$$

2.3.1.2 Instar wise larvalprogression(%)

The number of worms retained in different treatments upto spinning stagewasrecordedandthepercentlarvalprogressionwascalculatedbyusingtheformula,

$$\text{Per cent larval progression} = \frac{\text{Number of larvae alive per treatment}}{\text{Total number of worms per treatment}} \text{ X } 100$$

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2.3.1.3 Total larval duration (days)

The time taken by larvae to spin the cocoon recorded and countingthetotal duration.

2.3.1.4 Grown up larvalweight(5th instar 5th dayin g/larva)

The weight of ten randomly picked silkworms was recorded on 5th day of 5th instar. The observations were recorded separately for each replication and the average ofthesame wascomputed toobservetheeffect ofspray of different chemicals.

2.3.1.5 EffectiveRateofRearing (ERR)(%)

The number of cocoons harvested at the end of rearing were counted and theERRwas calculated by using formula,

$$\text{ERR (\%)} = \frac{\text{Number of cocoons harvested}}{\text{Number of larvae treated}} \text{ X } 100$$

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2.4 Statistical analysis

The data collected from the experimental field and silkworms rearing wereanalyzed statistically by using one-way RCBD and CRD for testing of significance by Fisher's method of analysis of variance as outlined by Sundaraaj*et al*. (1972). The level of significance used in the F-test was P = 0.05. The critical difference (CD) values were computed to compare significance of the treatments.

3. Results and discussion

The efficacy of pesticides in mulberry ecosystem is determined not only by theireffect against the target pest but also their safety to silkworms. Studies were conductedtodeterminetheresidualeffectandthesafetyperiodoffeedingsilkworms with the leaves harvested from pesticidesprayed mulberry garden. The observations are documented and discussed inthissection.

3.1 Larval mortality (%)

The selected pesticides were sprayed on the mulberry and the leaves were fed to the silkworms at different day after spray. The number of larvae died duringthird, fourth and fifth instars were recorded separately in different treatments and the per cent mortality was calculated.

The third instar larvae did not show mortality in any of the treatments.But, the fourth and fifthinstar larvae exhibited considerable mortality upon feeding the leaves harvested from pesticidetreatedplants at different durations after spray of the chemical. However, the control treatments did not document the mortality at any stage of larval development (Figure 1).

Among the chemicals sprayed, during fourth instar, zero per cent mortality wasobservedindifferenttreatments*viz.*,diafenthiuron 50% WP (@ 1 g/lit), abamectin 1.9% EC (@ 0.75ml/lit) at both 15 and 21 DAS whileit wassignificantly high when the leaves harvested from diafenthiuron 50% WP (@ 1 g/lit) at 8 DAS (8.89 and 6.67 %) on par with abamectin 1.9% EC (@ 0.75ml/lit) at 8 DAS (7.78 %), azadirachtin 10000 ppm (@ 1ml/lit) (6.67 and 10.00 %) followed by cyenopyrafen 30% EC (@ 0.5ml/lit) (5.56 %) respectively during Jan-Feb, 2023 and Mar-April, 2023.

During fifth instar, the mortality rate was significantly high when the silkworms were fed with leaves harvested at 8 DAS of diafenthiuron 50% WP (@ 1 g/lit) (10.00 and 14.4 %), abamectin 1.9% EC (@ 0.75ml/lit) (8.89 and 11.11 %) and 20 DAS of azadirachtin 10000 ppm (@ 1ml/lit) (12.22 %) followed by cyenopyrafen 30% EC (@ 0.5ml/lit) (2.22 and 6.67%), respectively during Jan-Feb, 2023 and Mar-April, 2023.

However, there was no mortality observed when the leaves harvested at 15 and 21 DAS of both diafenthiuron 50% WP (@ 1 g/lit) and abamectin 1.9% EC (@ 0.75ml/lit) were used for rearing the silkworms. Vomiting symptoms and Shrunken body was observed in azadirachtin 10000 ppm (@ 1ml/lit) cyenopyrafen 30% EC (@ 0.5ml/lit) respectively. Though diamethoate 30% EC (@ 2 ml/lit) recorded zero mortality during Jan-Feb, 2023 there was a 2.22 % mortality observed during Mar-April, 2023 among the standard checks (Table 2).

Silkworm,*B. mori* is a beneficial insect rearedfor cocoon production. Hence,any molecule used for control of different pests in mulberry willhave an impact on growth and productivity of silkworms. The toxic residue of insecticides may rupture the integument, cause complete cessationoffeeding,stiffnessinbodyresultingin'S'or'C'shapedlarvae,vomitingandincomplete ecdysis (Jyothi *et al.*, 2013), exhibited shrinkage of the body duetomusclecontraction(Jyothi*etal.*,2019)uponfeedingtheleaves harvested frompesticide sprayedmulberry plot. Hence, a specific waiting period issuggested for safe use of such chemicals (Yokoyama, 1962).

The chemical molecules belonging to the group of macrocyclic lactones likeemamectin benzoate 5% SG (Kordy, 2014), biological molecules likespinosad 48 SCat 100g a.i./ha (Mathiranjan and Raguraman, 2013) and neonicotinoids like thiamethoxam 0.2 ml/lit were found toxic reportinghighest larval mortality in silkworms even after 48-72 hours of spray and upto 50 DAS.The pyridine organic compounds like flonicamid 50 WG @ 0.3 g/lit (Yeshika*et al.*,2019), ryanoid class of molecules like chlorantraniliprole andnew generation green insecticide flubendiamide (Kumar*et al.*, 2017) belonging to theclassdiamidesalsorecorded93-100percentmortalityinsilkwormsduetopersistenttoxicityinthemulberryleavesevenafter10DASofpesticides. However, Narayanaswamy *et al.* (2017) reported lowest larval mortality (2.11 %) upon feeding silkworms with NSKE (4%) treated mulberry leaves on 22nd day after spray. Kumar *et al.* (2019) observed 100.00, 75.00, 50.33, 10.00 and 12.00 per cent mortality on 10, 15, 20, 25 and 30 DAS, respectively when the silkworms were fed on mulberry leaves sprayed with azadirachtin 0.03 EC (@ 2. 0 ml/lit). Bandyopadhyay *et al.* (2013) reported that neem oil @ 1500 ppm and azadirachtin 1 per cent recorded silkworm mortality of 10.80 per cent and 11.60 per cent at 7 DAS, 6.3 per cent and 8.3 per cent at 14 DAS, respectively.

Kalpana*et al*. (2022) among six selected chemical molecules abamectin 1.9% EC (@ 0.75 ml/lit) and diafenthiuron 50% WP (@ 1 g/lit) at 15 and 20 DAS were found safer to silkworms and recorded zero mortality at third, fourth and fifth instar silkworms.

Figure 1: Pesticide toxicity symptoms observed in silkworm, *Bombyx. mori* L

A. Healthy worms (Control)

B. Vomiting of gut juice (Azadirachtin1% EC @ 1ml/lit)

C. Dead worms (Azadirachtin1% EC @ 1ml/lit)

D. Shrunken body (Cyanopyrafen30% EC @ 0.5ml/lit)

Table 2: Larval mortality (%) of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different durations after spray

Treatments	Period of treatment								
	3^{rd} instar			4^{th} instar			5^{th} instar		
	Jan-Feb 2023	Mar-Apr 2023	Average	Jan-Feb 2023	Mar-Apr 2023	Average	Jan-Feb 2023	Mar-Apr 2023	Average
T_1	0.00	0.00	0.00	8.89^{a}	6.67^{ab}	7.78^{a}	10.00^{a}	14.44^{a}	12.22^{a}
T_2	0.00	0.00	0.00	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{d}	0.00^{b}
T_3	0.00	0.00	0.00	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{d}	0.00^{b}
T_4	0.00	0.00	0.00	7.77^{a}	7.77^{ab}	7.77^{a}	8.89^{a}	11.11^{ab}	10.00^{a}
T_5	0.00	0.00	0.00	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{d}	0.00^{b}
T_6	0.00	0.00	0.00	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{d}	0.00^{b}
T_7	0.00	0.00	0.00	0.00^{b}	2.22^{bc}	1.11^{b}	0.00^{b}	2.22^{cd}	1.11^{b}
T_8	0.00	0.00	0.00	5.56^{ab}	5.56^{abc}	5.56^{ab}	1.11^{b}	6.67^{bc}	3.89^{b}
T_9	0.00	0.00	0.00	6.67^{a}	10.00^{a}	8.33^{a}	12.22^{a}	12.22^{a}	12.22^{a}
T_{10}	0.00	0.00	0.00	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{d}	0.00^{b}
T_{11}	0.00	0.00	0.00	0.00^{b}	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{d}	0.00^{b}
F-test	NS	NS	NS	*	*	*	*	*	*
S. Em ±	-	-	-	1.835	1.925	1.692	1.161	1.571	1.173
$CD_{0.05}$	-	-	-	5.418	5.682	4.994	3.424	4.638	3.461
CV	-	-	-	1.036	3.82	3.466	6.583	4.153	5.637

*Significant at 0.05; DAS: Days After Spray of the chemical; NS :Non significant; Numbers superscript with same alphabets are statistically on par

3.2 Larval progression

The larval progression showed a significant difference between the treatments during different stages of the silkworm. Cent per cent progression of larva was observed in all treatments during third instar. The molecules, diafenthiuron 50% WP (@ 1 g/lit) and abamectin 1.9% EC (@ 0.75ml/lit) recorded 100 per cent larval progression at 15 and 21 DAS, along with the control treatments that were on par with dimethoate 30% EC (@ 2 ml/lit) in fourth and fifth instars during both rearings (100.00, 97.78 %, respectively during Jan-Feb, 2023 and Mar-April, 2023). The fourth instar larval progression registered least values in azadirachtin 10000 ppm (@ 1ml/lit) (93.33 and 89.98 %) on par withdiafenthiuron 50% WP (@ 1 g/lit) (91.11 and 93.33 %) and abamectin 1.9% EC (@ 0.75ml/lit) (92.22 and 92.22%) at 8 DAS followed by cyenopyrafen 30% EC (@ 0.5ml/lit) (94.44 and 94.44 %) during Jan-Feb, 2023 and Mar-April, 2023, respectively.

During fifth instar, the larvalprogression recorded least in azadirachtin 10000 ppm (@ 1ml/l) (87.72 and 86.66 %) on par with diafenthiuron 50% WP (@ 1 g/lit) (89.89 and 85.55 %) and abamectin 1.9% EC (@ 0.75ml/lit) (91.11 and 88.89 %) at 8 DAS followed by cyenopyrafen 30% EC (@ 0.5ml/lit) (97.78 and 94.44 %) during Jan-Feb, 2023 and Mar-April, 2023 respectively. But the progression increased to 100 cent in both diafenthiuron 50% WP (@ 1 g/lit) and abamectin 1.9% EC (@ 0.75ml/lit) when used at 15 and 21 DAS, which is on par with control (water spray) and absolute control (Table 3, Figure 2).

Mao *et al*. (2019) reported minimum survival rate in chlorantraniliprole treated group (97.50%) compared to control group (100%).In a similar vein, fenpropathrin showed decreased larval progression in both 15 and 20 DAS, demonstrating that the pyrethroid group is not recommended for use in sericulture and can seriously harm silkworm growth and development by attacking the insect nerve membranes and impairing nerve conduction (Fritz *et al*., 2013).

Figure 2: Larval progression (%) of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray

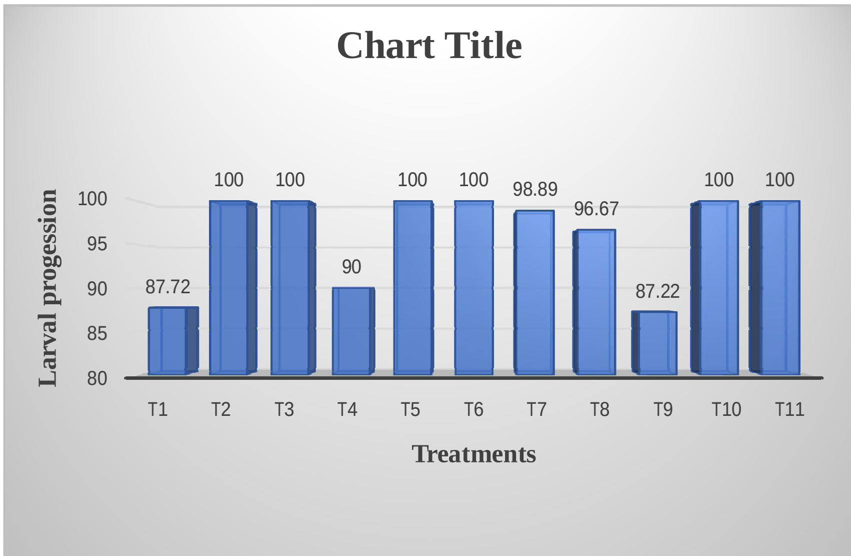


Table 3: Larval progression (%) of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray

Treatments	Period of treatment								
	3rd instar			4th instar			5th instar		
	Jan-Feb, 2023	Mar-Apr, 2023	Average	Jan-Feb, 2023	Mar-Apr, 2023	Average	Jan-Feb, 2023	Mar-Apr, 2023	Average
T_1	100.00	100.00	100.00	91.107^{c}	93.33^{bc}	92.22^{c}	89.89^{b}	85.55^{c}	87.72^{b}
T_2	100.00	100.00	100.00	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
T_3	100.00	100.00	100.00	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
T_4	100.00	100.00	100.00	92.22^{c}	92.22^{bc}	92.22^{c}	91.11^{b}	88.89^{c}	90.00^{b}
T_5	100.00	100.00	100.00	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
T_6	100.00	100.00	100.00	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
T_7	100.00	100.00	100.00	100.00^{a}	97.78^{ab}	98.89^{ab}	100.00^{a}	97.78^{ab}	98.89^{a}
T_8	100.00	100.00	100.00	$94.44^{a c}$	94.44^{abc}	94.44^{bc}	98.89^{a}	94.44^{b}	96.67^{a}
T_9	100.00	100.00	100.00	93.33^{c}	89.98^{c}	91.66^{c}	87.77^{b}	86.66^{c}	87.22^{b}
T_{10}	100.00	100.00	100.00	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
T_{11}	100.00	100.00	100.00	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}
F-test	NS	NS	NS	*	*	*	*	*	*
S. Em ±	-	-	-	1.84	1.924	1.516	1.18	1.60	1.273
$CD_{0.05}$	-	-	-	5.42	5.68	4.475	3.473	4.741	3.758
CV	-	-	-	3.26	3.434	2.701	2.101	2.890	2.287

*Significant at 0.05; DAS: Days After Spray of the chemical; NS : Non significant; Numbers superscript with same alphabets are statistically on par.

3.3 Grown up larval weight (g/larva)

The average weight of grown up larva (5th day of 5th instar) ofdouble hybrid (FC1 x FC2) silkwormswas recorded separately among different treatments. Significantly larvae with maximum weight were observed when silkworms were fed with mulberry leaves harvested from abamectin 1.9 % EC @ (0.75ml/lit) sprayed plants (4.37 and 4.19 g/larva) at 15 DAS on par with diafenthiuron 50% WP (@ 1 g/lit) (4.26 and 4.09 g/larva) at 15 DAS, abamectin 1.9% EC (@ 0.75ml/lit) (4.16 and 3.99 g/larva) at 21 DAS and diafenthiuron 50% WP (@ 1 g/lit) (4.14 and 3.97 g/larva) at 21 DAS, respectively during Jan-Feb, 2023 and Mar-April, 2023. The least larval weight was observed in diafenthiuron 50 % WP (@ 1 g/lit) (3.50 and 3.66 g/larva) at 8 DAS followed by azadirachtin 10000 ppm (@ 1ml/lit) (3.79 and 3.41 g/larva), abamectin 1.9% EC (@ 0.75ml/lit) (4.02 and 3.63 g/larvae) at 8 DAS, cyenopyrafen 30% EC (@ 0.5ml/lit) (3.89 and 3.70 g/larva) and diamethoate 30% EC (@ 2 ml/lit) (3.77 and 3.86 g/larva) during Jan-Feb, 2023 and Mar-April 2023, respectively (Table 4, Figure 3).

Apart from various modes of action, the pesticide molecules may also deter the pest from feeding ultimately reflecting on the loss of body weight. The chemical molecules like fenpropathrin (Khan *et al*., 2014) are known to have both repellent and anti-feeding activity that may result in reduced larval weight in silkworm, *B. mori*. L (Maria *et al.* 2000 and Hoda, 2011).

Figure 3: Larval weight of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray

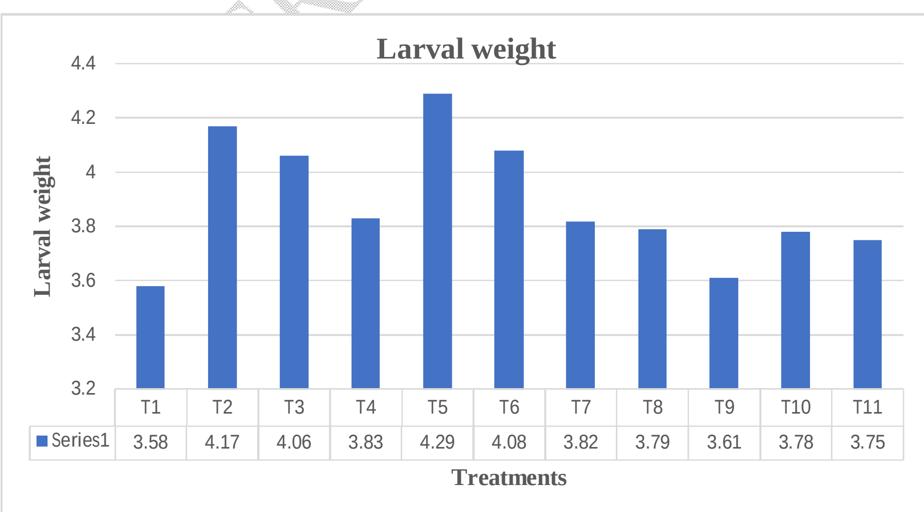


Table 4: Larval weight and duration of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray

Treatments	Period of treatment					
	Grown up larval weight (g)			Total larval duration (Days)		
	Jan-Feb, 2023	Mar-Apr, 2023	Average	Jan-Feb, 2023	Mar-Apr, 2023	Average
T_1	3.50^{e}	3.66^{de}	3.58^{e}	25.50^{a}	23.73^{bc}	24.62^{ab}
T_2	4.26^{ab}	4.09^{ab}	4.17^{ab}	22.97^{g}	22.57^{efg}	22.77^{fg}
T_3	4.14^{abc}	3.97^{bc}	4.06^{b}	23.13^{fg}	23.00^{de}	23.07^{ef}
T_4	4.02^{bcd}	3.63^{ef}	3.83^{c}	24.50^{c}	23.77^{abc}	24.13^{bc}
T_5	4.37^{a}	4.19^{a}	4.29^{a}	22.40^{h}	22.20^{fg}	22.30^{gh}
T_6	4.16^{ab}	3.99^{abc}	4.08^{b}	23.57^{ef}	22.87^{def}	23.22^{ef}
T_7	3.77^{de}	3.86^{cd}	3.82^{cd}	24.71^{bc}	24.47^{a}	24.59^{ab}
T_8	3.89^{cd}	3.70^{de}	3.79^{cde}	24.20^{cd}	23.53^{cd}	23.87^{cd}
T_9	3.79^{d}	3.413^{f}	3.61^{de}	25.13^{ab}	24.40^{ab}	24.77^{a}
T_{10}	3.88^{cd}	3.69^{de}	3.78^{cde}	23.87^{de}	23.17^{cde}	23.52^{de}
T_{11}	3.85^{d}	3.64^{def}	3.75^{cde}	22.17^{h}	22.00^{g}	22.08^{h}
F-test	*	*	*	*	*	*
S. Em ±	0.082	0.071	0.072	0.172	0.232	0.162
$CD_{0.05}$	0.252	0.201	0.195	0.490	0.684	0.471
CV	3.671	3.111	2.947	1.221	1.712	1.168

Larval weight is the average weight (g) of 10 larvae weighed on 5th days of IV instar*Significant at 0.05; DAS: Days After Spray of the chemical; NS : Non significant; Numbers superscript with same alphabets are statistically on par

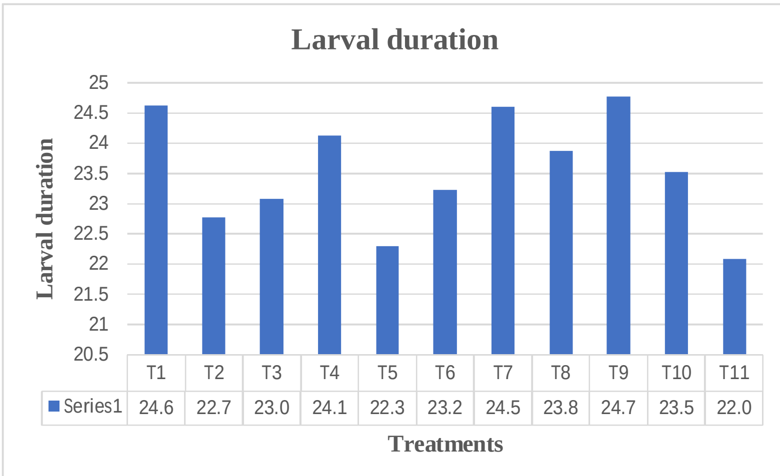
3.4 Total larval duration (days)

The larval duration showed significant difference among the treatments when silkworms were fed with mulberry leaves harvested at different duration of spray of the selected chemicals. The shortest total larval duration was observed upon feeding the leaves harvested from absolute control plot (22.17 and 22.00 days, respectively during Jan-Feb, 2023 and Mar-April, 2023).

Among the chemicals used in the experiment, the least larval duration was recorded in abamectin 1.9% EC (@ 0.75ml/lit) at 15 DAS (22.40 and 22.20 days) on par with diafenthiuron 50% WP (@ 1 g/lit) at 15 DAS (22.97 and 22.57 days) followed by abamectin 1.9 % EC (@ 0.75ml/lit) (23.57 and 22.87 days), diafenthiuron 50% WP (@ 1 g/lit) (23.13 and 23.00 days) at 21 DAS, respectively during Jan-Feb, 2023 and Mar-April, 2023. The larval durationextended significantly when the silkworms were with fed with mulberry leaves harvested from the plot sprayed with diafenthiuron 50% WP (@ 1 g/lit) at 8 DAS (25.50 and 23.73 days) on par with azadirachtin 10000 ppm (@ 1ml/lit) (25.23 and 24.40 days) followed by abamectin 1.9% EC (@ 0.75ml/lit) at 8 DAS (24.50 and 23.77 days) during Jan-Feb, 2023 and Mar-April, 2023, respectively (Table 4, Figure 4).

The high residual content of insecticide molecules in the initial days of spraymightresultinalterationsinthenormalphysiologicalprocessesinthesilkwormandthis residual toxicity may reduce with increased safety period (Kumutha *et al.,* 2013).The insecticide interferes with the release of the hormones essential for metamorphosisresulting in delaying of instar duration (Tiwari *et al.*, 2006). The altered physiologymightresultinextendedlarvalduration(Singh*etal.*,2008).The chemicals such as dimethoate and methyl parathion (Misra *et al.*, 2003) and many suchinsecticides (Kumar*et al*., 2017 and Yeshika *et al.,* 2019) prolong the instarduration when silkworms are fed with treated mulberry leaves harvested at differentdaysafter spray.

Figure 4: Larval duration of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray



3.5 Effective Rate of Rearing (ERR) (%)

The ERR of silkworm rearing was calculated among different chemicals used to spray on mulberry for effective management of thrips and mite pests. A significant difference was noticed among the treatments (Table 5) with respect to per cent ERR that recorded maximum with water spray (95.57 and 97.78 %) followed by absolute control (93.33 and 96.67 %) during Jan-Feb, 2023 and Mar-April, 2023, respectively.

Among the chemicals used, abamectin 1.9% EC (@ 0.75ml/lit) anddiafenthiuron 50% WP (@ 1 g/lit) at 15 (97.78 and 97.78 %, 97.78 and 97.78 %, respectively) and 21 (95.55 and 97.78%, 95.55 and 97.78 %, respectively) DAS, recorded significantly maximum ERR that was on par with diamethoate 30% EC (@ 2 ml/lit)(97.78 and 95.56) and cyenopyrafen 30% EC (@ 0.5ml/lit) (96.67 and 90.00) during Jan-Feb, 2023 and Mar-April, 2023, respectively. The least ERR was recorded in the treatment with azadirachtin 10000 ppm (@ 1ml/lit) (72.22 and 71.11) followed by diafenthiuron 50% WP (@ 1 g/lit) (78.89 and 76.66 %) and abamectin 1.9% EC (@ 0.75ml/lit) at 8 DAS (86.67 and 83.33 %) during Jan-Feb, 2023 and Mar-April, 2023, respectively (Table 5, Figure 5).

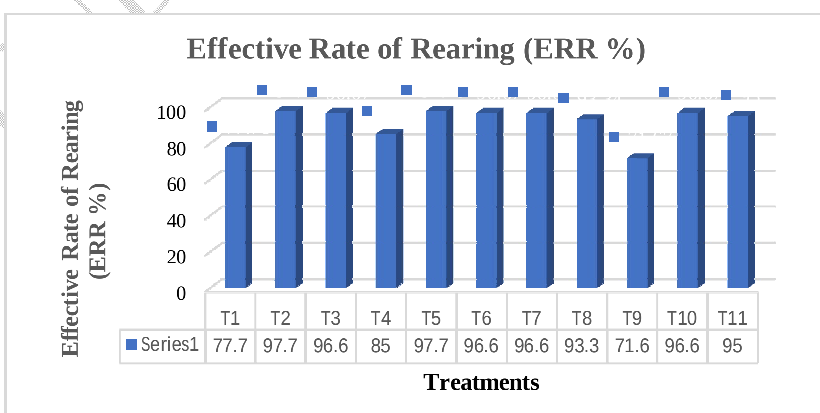
Yeshika *et al.* (2019) reported lowest ERR when the silkworms were fed with insecticide, flonicamid 50 WG (@ 0.15 g/lit) treated mulberry leaves at 10 DAS. But, Poornima (2013) recorded ERR of 96 per cent ERR upon feeding the silkworms with diafenthiuron 50% WP treated mulberry leaves, which is in accordance with the current report.

Table 5 : Effective Rate of Rearing (ERR %) of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray

Treatments	Period of treatment		Average
	Jan-Feb, 2023	Mar-Apr, 2023	
T_1	78.89[bc]	76.66[c]	77.78[cd]
T_2	97.78[a]	97.78[a]	97.78[a]
T_3	95.56[a]	97.78[a]	96.67[a]
T_4	86.67[ab]	83.33[bc]	85.00[bc]
T_5	97.78[a]	97.78[a]	97.78[a]
T_6	95.55[a]	97.78[a]	96.67[a]
T_7	97.78[a]	95.56[a]	96.67[a]
T_8	96.67[a]	90.00[ab]	93.34[ab]
T_9	72.22[c]	71.11[c]	71.67[d]
T_{10}	95.57[a]	97.78[a]	96.67[a]
T_{11}	93.33[a]	96.67[a]	95.00[a]
F-test	*	*	*
S. Em ±	3.561	3.691	2.858
$CD_{0.05}$	10.511	10.880	8.435
CV	6.732	7.010	5.417

*Significant at 0.05; DAS: Days After Spray of the chemical; NS : Non significant; Numbers superscript with same alphabets are statistically on par

Figure 5: Effective Rate of Rearing (ERR %) of silkworm, *B. mori* L. as influenced by feeding mulberry leaves sprayed with selected chemicals at different days after spray



4. Conclusion

Mites and thrips commonly infest mulberry trees simultaneously during dry seasons. Therefore, focusing on the management of these pests with the application of a single chemical molecule would be more beneficial. The selected chemicals should also be safe for silkworms, ensuring no mortality (0.00%) and continuous larval progression during the third, fourth, and fifth instars, with full larval development, normal larval weight, survival, and instar-wise progression. abamectin 1.9% EC (@ 0.75 ml/lit) and diafenthiuron 50%WP (@ 1 g/lit) can be used as an alternate molecule for effective management of both mulberrythripsand mites with a safety period of 15 days. These chemicals molecules are serve as viable alternatives to DDVP 76% EC for effectively managing both mulberry thrips and mites.

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