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EFFECT OF FEEDING PESTICIDES SPRAYED MULBERRY LEAVES ON REARING PARAMETERS OF SILKWORM

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ABSTRACT

A bioassay study was conducted to test the effect of feeding pesticides sprayed mulberry leaves on silkworms. The pesticides that are used to control mulberry pests were selected with the recommended dose as per the label claim and were sprayed on mulberry plants and fed to silkworms (FC1) at 5, 10, 15 and 20 days after spraying (DAS) to know their impact on the growth of silkworms. The results revealed that among the five pesticides tested, Azadirachtin 1 per cent (2 mL/L) and Chlorfenapyr 10 SC (1.5 mL/L) were highly toxic to silkworms with maximum larval mortality of 100 and 23.5 per cent even at 10 days after spray, but less toxic at 15 days after spray, respectively. However, the pesticide Orgomite (2.5 mL/L) a botanical formulation recorded the least mortality of silkworm (7.83%) at 10 days after spray. Whereas, the pesticides Wettable Sulphur 80 WP (2 g/l) and Era Safeguard (2.5 mL/L) at 10 DAS recorded less mortality of 8.30 and 17.25 per cent, respectively. Similar trends were recorded with regard to the rearing parameters of silkworms. The findings of the current study have clearly shown that the Orgomite which is a botanical formulation was proved to be the least toxic to silkworms even at 10 DAS followed by Wettable Sulphur 80 WP, Era Safeguard, Chlorfenapyr 10 SC and Azadirachtin 1 per cent at 15 DAS. Thus, Orgomite and Chlorfenapyr 10 SC were found best for the management of both mites and leaf roller with a safety period of 10 and 15 days after pesticide spray, respectively.

Key words : Bioassay, Pesticide, Mulberry, Silkworm, Mortality.

Introduction

Sericulture is an admixture of forestry, agriculture, industry and art for the production of raw silk. India has a huge potential for sericulture development unlike other agro-industries since sericulture is a unique agro-based cottage industry comprising several components such as cultivation of mulberry, production of disease-free layings, rearing of silkworms, production and marketing of cocoons, reeling of cocoons and weaving fabrics.

Mulberry leaf is the major economic component in silkworm rearing. It is a perineal crop that can be cultivated on both rainfed and irrigated land and maintained for more than 10-15 years. It is the exclusive food and only source of nutrition for silkworm, *Bombyx mori* L. Cocoon productivity and profit to the farmers mainly depend upon the quality as well as quantity of mulberry leaves which influences silkworm growth and development. In recent years, due to sudden changes in climatic conditions and repeated harvesting mulberry has become susceptible to many pests and diseases resulting in a considerable reduction in leaf yield and quality. The excessive use of chemicals for both mulberry cultivation and pest management reduces the quality of mulberry leaf. Feeding of such leaves to silkworms resulted in adverse effects on both silkworm rearing and cocoon parameters.

The use of insecticides for pest management in mulberry should be selective as they can pose a danger to silkworms. New generation chemicals are available in the market, which is quite effective and selecting the best insecticides compared to old ones requires assessing their efficiency against pests of mulberry and their safety period for silkworms. In light of the above, a study was conducted to know the Effect of feeding pesticides sprayed mulberry leaves on the rearing parameters of silkworms.

Materials and Methods

The experiment was carried out at the College of Agriculture, KVK, Chamarajanagara during 2022-23 in a well established V-1 mulberry garden. To know the effect of feeding insecticide-treated mulberry leaves on silkworm rearing, commercial bivoltine silkworm hybrids (FC1) were reared by following standard silkworm rearing practices outlined by Dandin and Giridhar (2014). The eggs of commercial bivoltine silkworm hybrids (FC1) were procured from NSSO, CSB, Bengaluru. Black boxing was done for 48 hours at pin head stage followed by exposure to diffused light to obtain maximum and uniform hatching. The newly hatched larvae were transferred from the egg sheet to the paraffin paper in the rearing tray. The hatched larvae were fed with finely chopped fresh and tender V-1 mulberry leaves till the fourth instar. After 30 minutes of initial feeding during the fourth instar, 50 larvae were transferred to the labeled experimental trays of each treatment. During the fifth instar, the silkworms were fed with the mulberry leaves sprayed with 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 per cent (2 mL/L) at interval of 5, 10, 15 and 20 days after spraying (DAS). The generated data is laid out in Randomized Complete Block Design (RCBD) with seven treatments and four replications.

Results and Discussion

Larval mortality

The larval mortality was found to be higher in all the batches of silkworms at 5 days after spray and decreased with an increase in interval after spray. Among the five pesticides treated, the maximum larval mortality was found in the silkworm batches fed with Azadirachtin 1 per cent (100%) followed by Chlorfenapyr 10 SC (23.25%), Era Safeguard (17.25%) and lowest in case of Orgomite (7.83%) sprayed batch at 10 days after spray followed by Wettable Sulphur 80 WP (8.30%). Whereas, there is no significant difference between larval mortality of all the treatment groups at 15 and 20 DAS (Table 1).

Fig. 1 : General view of silkworm rearing.

The highest mortality in Azadirachtin might be due to the presence of a biologically active compound that possesses a potential antifeedant effect (Rao and Raja, 2016). Chlorfenapyr is a pyrrole-based insecticide that mainly obstructs the respiration of insects through the de-coupling of oxidative phosphorylation, making the insects unable to produce energy and leading to paralysis of the body. So that they cannot carry out normal physiological activities and die (Yang *et al.*, 2019). This might be the reason for larval mortality even up to 15 DAS. Similarly, Narayanawamy *et al.* (2017) reported that the worms fed with NSKE (4%) treated mulberry leaves on the 22nd day after spray recorded the lowest

Table 1 : Effect of feeding the insecticide 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	73.66	23.25	7.93	2.14
T_2: Wettable Sulphur 80 WP @ 2 g/l	32.25	8.30	4.22	0.25
T_3: Orgomite @ 2.5 mL/L	18.41	7.83	3.13	0.00
T_4: Era Safeguard @ 2.5 mL/L	67.49	17.25	7.08	1.78
T_5: Azadirachtin 1 % @ 2 mL/L	100.00	100.00	6.47	0.50
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 ±	15.30	9.45	2.03	0.67
CD @ 5%	45.47	28.09	-	-

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

Table 2 : Effect of feeding the insecticide 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	2.76	2.85	2.94	3.02
T_2: Wettable Sulphur 80 WP @ 2 g/l	2.88	2.93	2.99	3.09
T_3: Orgomite @ 2.5 mL/L	2.96	3.00	3.04	3.10
T_4: Era Safeguard @ 2.5 mL/L	2.81	2.87	2.95	3.04
T_5: Azadirachtin 1 % @ 2 mL/L	-	-	2.97	3.08
T_6: Water spray	3.07	3.08	3.09	3.10
T_7: Untreated control	3.10	3.10	3.10	3.10
F-test	**	**	NS	NS
S.Em ±	0.06	0.08	0.06	0.06
CD @ 5 %	0.18	0.23	-	-

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

Table 3 : Effect of feeding the insecticide 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	240.19	229.98	225.18	223.08
T_2: Wettable Sulphur 80 WP @ 2 g/l	223.56	223.56	223.02	220.92
T_3: Orgomite @ 2.5 mL/L	220.92	221.34	221.64	220.14
T_4: Era Safeguard @ 2.5 mL/L	238.39	226.26	223.80	222.96
T_5: Azadirachtin 1 % @ 2 mL/L	-	-	223.08	221.58
T_6: Water spray	220.14	220.38	219.60	219.36
T_7: Untreated control	218.40	218.40	218.40	218.40
F-test	**	**	NS	NS
S.Em ±	2.91	1.51	5.34	2.26
CD @ 5 %	8.65	4.50	-	-

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

larval mortality (2.11%) without affecting economic parameters of silkworm (PM × CSR2) when compared to other concentrations. Kumar *et al*. (2019) reported that silkworms fed on mulberry leaves sprayed with Azadirachtin 0.03 EC (2.0 mL/L) caused 100 per cent larval mortality on 10 DAS.

Fifth instar larval weight

The batch of silkworms fed on mulberry leaves sprayed with Orgomite 10 DAS recorded a significantly higher larval weight of 3 g followed by Wettable Sulphur 80 WP (2.93 g) and Era Safeguard (2.87 g). Whereas, Chlorfenapyr 10 SC and Azadirachtin 1 per cent were found safer to silkworms at 15 DAS recorded the larval weights of 2.94 g and 2.97 g, respectively. However, it was noticed that there was no significant difference between the data regarding fifth instar larval weight at 15 and 20 days after spray. The decrease in larval weight might be due to decreased uptake of nutrients from the leaf, increased metabolic activity of treated worms to combat pesticide effects, decreased enzymatic activity of digestive juice and loss of digestive fluid during vomiting, diarrhea, and starvation. The decrease in larval weight in the Azadirachtin-treated batches could be attributed to its antifeedant properties. Maria *et al*. (2000) reported that some insecticides are known to reduce the weight of silkworm larvae fed on mulberry leaves sprayed with them.

These results are in accordance with the findings of Narayanaswamy *et al*. (2017), who reported that the worms fed with NSKE-treated mulberry leaves at the 16th, 17th, 18th and 19th days after spray recorded significant minimum larval weight of 2.55, 2.57, 2.59 and 2.62 g, respectively. Patnaik *et al*. (2011) revealed a decrease in silkworm larval weight (2.49 g/larva) when fed Thiamethoxam (0.015%) treated mulberry leaves compared to control (2.51 g/larva). Kumutha *et al*. (2013) reported that a higher concentration of pesticide (Vijay neem) had affected silkworm larval weight in a higher percentage than Dichlorvos.

Fifth instar larval duration

In all intervals of spraying from 5 to 20 DAS, the larval duration was found maximum in case of silkworms fed with mulberry leaves treated with Chlorfenapyr 10 SC at 1.5 mL/L followed by Era Safeguard at 2.5 mL/L and minimum in water spray followed by Orgomite at 2.5 mL/L. At 10 DAS, the maximum fifth instar larval duration of 229.98 h was recorded in batches of silkworms fed on mulberry leaves sprayed with Chlorfenapyr 10 SC. Whereas, a minimum larval duration of 221.34 h was recorded in Orgomite treated batch. At 15 and 20 DAS, there was no significant difference between the larval duration of all the treatments (Table 3). However, larval

Table 4 : Effect of feeding the insecticide 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	24.41	73.84	90.19	96.32
T_2: Wettable Sulphur 80 WP @ 2 g/l	66.16	90.30	91.89	98.41
T_3: Orgomite @ 2.5 mL/L	79.50	91.02	92.67	98.75
T_4: Era Safeguard @ 2.5 mL/L	30.85	78.27	90.25	96.50
T_5: Azadirachtin 1 % @ 2 mL/L	-	-	91.77	98.13
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	9.75	2.21	0.98
CD @ 5 %	45.01	28.98	6.57	-

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

Table 5 : Effect of feeding the insecticide treated mulberry leaves on single cocoon weight.

Treatment details	Single cocoon weight (g)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10 % SC @ 1.5 mL/L	1.72	1.76	1.79	1.83
T_2: Wettable Sulphur 80 WP @ 2 g/l	1.79	1.83	1.84	1.88
T_3: Orgomite @ 2.5 mL/L	1.81	1.85	1.87	1.89
T_4: Era Safeguard @ 2.5 mL/L	1.76	1.78	1.80	1.84
T_5: Azadirachtin 1 % @ 2 mL/L	0.00	0.00	1.82	1.87
T_6: Water spray	1.91	1.91	1.91	1.91
T_7: Untreated control	1.90	1.90	1.90	1.90
F-test	**	**	NS	NS
S.Em ±	0.04	0.05	0.05	0.04
CD @ 5 %	0.12	0.15	-	-

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

duration was less in 20 days after spray and maximum in 5 days after spray in both the breeds indicating that the safety period increases results in better larval duration.

Santorum *et al*. (2019) reported the extended larval duration when silkworms fed with pesticide (Novaluron) sprayed mulberry leaves, which affected the release of hormones essential for metamorphosis. Similarly, Kumar *et al*. (2019) reported an extended larval duration when silkworms were fed on mulberry leaves treated with Azadirachtin 0.03 percent EC at 2mL/L on 15 DAS (215.33 h), 20 DAS (205.56 h), 25 DAS (190.00 h) and 30 DAS (184.00 h). Yeshika *et al*. (2019) noticed that Azadirachtin one per cent at 1 mL/L caused the longest fifth instar larval duration at 10 DAS (221.83 h), followed by 20 DAS (220 h) and 40 DAS (217 h). In addition, Narayanaswamy *et al*. (2017) noticed an increase in fifth instar larval duration when silkworms fed with mulberry leaves treated with 4 percent NSKE.

The effective rate of rearing (ERR)

Among all the pesticide treatments on 5 to 10 DAS, the effective rate of rearing was found maximum in case of Orgomite (91.02%), followed by Wettable Sulphur 80 WP (90.30%) treated batch and minimum ERR was recorded in case of silkworms fed with mulberry leaves treated with Chlorfenapyr 10 SC (73.84 %) followed by Era Safeguard (78.27%). At 15 DAS, a maximum ERR of 92.67 per cent was recorded in silkworm batches fed on mulberry leaves treated with Orgomite and the minimum was in a Chlorfenapyr 10 SC treated batch. However, the ERR of 91.89, 91.77 and 90.25 per cent was recorded in silkworm batches fed with mulberry leaves treated with Wettable Sulphur 80 WP, Azadirachtin 1 per cent and Era Safeguard, respectively. Whereas, there was no significant difference between the ERR of all the treatments at 20 DAS. However, the increase in ERR was noticed as days the safety period increases (20 DAS) irrespective of the chemicals.

The difference in the effective rate of rearing (ERR) between treatments might be due to the silkworm mortality brought out by the insecticidal residue in each treatment. Similarly, mulberry leaves Administered with 1 per cent neem oil showed 93 per cent ERR when given to silkworms at 15 days after spraying (Bandyopadhyay *et al*., 2013). One per cent Azadirachtin at 2 mL/L sprayed mulberry leaves when fed to silkworms at 16 days after spray resulted in 94.66 per cent ERR (Sharath *et al*., 2022).

Single cocoon weight

At 5 days after spray, all the insecticide treatments significantly affected cocoon weight over water water spray and untreated control. At 10 DAS, cocoon harvested from silkworm batches fed with Orgomite treated leaves had recorded higher cocoon weight (1.85 g). Whereas,

Table 6 : Effect of feeding the insecticide treated mulberry leaves on cocoon shell weight.

Treatment details	Cocoon shell weight (g)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10 % SC @ 1.5 mL/L	0.236	0.257	0.272	0.286
T_2: Wettable Sulphur 80 WP @ 2 g/l	0.259	0.268	0.280	0.299
T_3: Orgomite @ 2.5 mL/L	0.265	0.275	0.285	0.304
T_4: Era Safeguard @ 2.5 mL/L	0.249	0.260	0.275	0.291
T_5: Azadirachtin 1 % @ 2 mL/L	-	-	0.278	0.295
T_6: Water spray	0.295	0.302	0.305	0.307
T_7: Untreated control	0.312	0.312	0.312	0.312
F-test	**	**	NS	NS
S.Em ±	0.004	0.007	0.009	0.008
CD @ 5 %	0.011	0.020	-	-

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

Table 7 : Effect of feeding the insecticide treated mulberry leaves on cocoon shell ratio.

Treatment details	Cocoon shell ratio (%)			
	5 DAS	10 DAS	15 DAS	20 DAS
T_1: Chlorfenapyr 10 % SC @ 1.5 mL/L	18.22	18.42	20.20	21.66
T_2: Wettable Sulphur 80 WP @ 2 g/l	19.59	20.98	20.99	22.03
T_3: Orgomite @ 2.5 mL/L	20.14	21.33	21.13	22.07
T_4: Era Safeguard @ 2.5 mL/L	18.32	18.67	20.57	21.94
T_5: Azadirachtin 1% @ 2 mL/L	-	-	20.86	22.02
T_6: Water spray	21.94	21.91	22.13	22.25
T_7: Untreated control	22.42	22.42	22.42	22.42
F-test	**	**	NS	NS
S.Em±	0.51	0.49	0.58	0.70
CD @ 5 %	1.53	1.45	-	-

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

the chemicals Chlorfenapyr 10 SC, Era Safeguard and Wettable Sulphur 80 WP recorded cocoon weights of 1.76, 1.78 and 1.83 g at 10 DAS, respectively. However, there was no significant difference between cocoon weight in all the treatments at 15 and 20 days after spray.

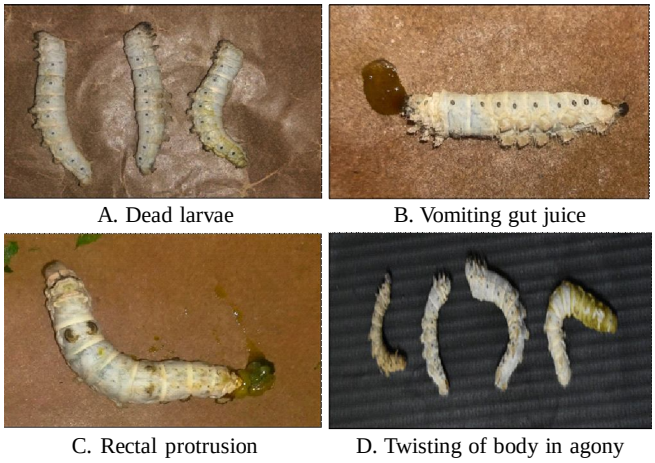
Similarly, Jiequn *et al*. (2019) reported that Chlorfenapyr (8% ME) treated mulberry leaves fed to silkworms on 15 and 30 days after spray exhibited cocoon weights of 2.01 and 2.05 g, respectively. Narayanaswamy *et al*. (2017) noticed a significant decrease in cocoon weight when silkworms fed with NSKE-treated leaves fed on the 16th, 17th, 18th and 19th days after spray recorded cocoon weights of 1.80, 1.84, 1.87 and 1.91 g, respectively. After a safe waiting period, feeding silkworms with mulberry leaves sprayed with Dimethoate resulted in a noticeable improvement in terms of cocoon weight (Kariappa and Narasimhanna, 1978).

Cocoon shell weight

Among the pesticide treatments, the cocoon shell weight was significantly higher in the cocoons harvested from the batches of silkworms fed on mulberry leaves treated with Orgomite (0.275 g) at 10 DAS, followed by Wettable Sulphur (0.268 g) and Era Safegaurd (0.260 g). Whereas, lower shell weight was recorded incase of Chlorfenapyr 10 SC (0.257 g) at 10 DAS. However, there was no significant difference between the shell ratio among the treatments at 15 and 20 DAS (Table 6). The present findings are in line with the results of Narayanaswamy *et al*. (2017), who reported that when silkworms fed with NSKE-treated leaves after the 16th, 17th, 18th and 19th day after spray recorded significantly lower shell weights of 0.30, 0.32, 0.33 and 0.35 g, respectively. Bandyopadhyay *et al*. (2013) reported that residual toxicity of neem-based pesticides (Azadirachtin 1500 ppm), Acephate 75 SP, Dichlorvos 76 E, and Monocrotophos 36 SL continues for at least up to 14 days, causing a decline in shell weight, filament length and denier. Yeshika *et al*. (2020) reported that the presence of novel pesticide molecule residues in mulberry leaves had an impact on the cocoon features of the silkworm. In comparison to Dichlorvos 76 EC, Dinotefuran 20 SG and Pymetrozine 50 WG, the results showed that untreated control had the highest single cocoon weight and cocoon shell weight.

Cocoon shell ratio

Among all the insecticides, the shell ratio (%) was found to be highest in silkworms fed on mulberry leaves sprayed with Orgomite (21.33%), followed by Wettable Sulphur 80 WP (20.98%) and lowest in treatment Chlorfenapyr 10 SC (18.42%) on 10 DAS. Whereas, there was an increase in shell ratio with an increased



A. Dead larvae B. Vomiting gut juice

C. Rectal protrusion D. Twisting of body in agony

Fig. 2 : Symptoms exhibited by silkworm fed on insecticides sprayed mulberry leaves.

safety period. However, there was no significant difference between the shell ratio among the treatments at 15 and 20 DAS (Table 7). The results are in line with the findings of Narayanaswamy *et al*. (2017), who reported that when silkworms fed with NSKE-treated leaves after the 16th, 17th, 18th and 19th day after spray recorded significantly lower shell ratios of 16.62, 17.28, 17.66 and 18.14 per cent, respectively. Jiequn *et al*. (2019) reported that Chlorfenapyr (8% ME) treated mulberry leaves fed to silkworms 15 and 30 days after spray exhibited a cocoon shell ratio of 19.06 and 18.09 per cent, respectively. Bhagyalakshmi *et al*. (1995) studied the effect of Hexachlorocyclohexane (HCH) on silkworms and reported a considerable reduction in cocoon weight and cocoon shell ratio due to HCH treatment.

Conclusion

The present study indicated that the insecticides Chlorfenapyr 10 SC, Azadirachtin 1 per cent and Era Safeguard were toxic to silkworms up to 15 days after spray. However, the insecticide Orgomite proved to be relatively safer for silkworm rearing 10 days after spraying followed by Wettable Sulphur 80 WP. Thus, Orgomite and Chlorfenapyr 10 SC could be the best insecticides to manage both mites and leaf roller with a safety period of 10 and 15 days after spray, respectively.

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