



Translaminar activity of different insecticides against *Bemisia tabaci*

NEERU DUMRA^{1*}, KRISHNA ROLANIA¹, SURENDER SINGH YADAV¹ and SONU KUMARI¹

Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana 125 004, India

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ABSTRACT

One of the main mechanisms of action for many insecticides is translaminar redistribution or local systemic. The present study was carried out at Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana during 2019 and 2020 to investigate the translaminar activity of different insecticides having different doses and sprays on treated brinjal plant having *Bemisia tabaci* (Gennadius) nymphs. Different treatments, i.e. diafenthiuron 50% WP (150, 210, and 300 g a.i./ha), fenpropathrin 30% EC (50, 70, and 100 g a.i./ha), thiamethoxam 25% WG (25, 35, and 50 g a.i./ha), and deltamethrin 2.8% EC (7.5, 10.5 and 15 g a.i./ha) were frequently sprayed on brinjal plants (var. Hisar Shyamal) growing in pots. Insecticides effectiveness was measured through nymphal mortality of *B. tabaci* (whitefly). Similar study was conducted in 2020 to ensure reliability of results. The results revealed that, almost similar trends were obtained during 2019 and 2020, hence proving reliability. Among all tested insecticides, maximum translaminar effect was observed in thiamethoxam 25% WG treated plant at 50 g a.i./ha (50.72% nymphal mortality). Whereas, deltamethrin 2.8% EC treated plant at 15 g a.i./ha showed minimum translaminar effect (0.63% nymphal mortality) as compared to other treatments. Translaminar effect of leaves treated with diafenthiuron 50% WP and fenpropathrin 30% EC was found at par with each other. Nymphal mortality is low in sub-lethal doses of insecticides as compared to lethal doses. It can be concluded that resistance may develop due to sub-lethal doses of insecticides. Farmers and agricultural experts would benefit from this study's findings.

Keywords: *Bemisia tabaci*, Insecticides, Nymph, Systemic, Translaminar

Vegetable farming is crucial for Indian agriculture because it provides nutritional, therapeutic and industrial significance (Kundu and Mandal 2020). Among the vegetables, brinjal (*Solanum melongena* L.), is grown as an annual crop in the tropics and subtropics. The crop is more susceptible to pest infestation from the seedling stage to harvest due to the crop's succulent character and cultivation under high moisture regimes. There are more than 70 different insect species that attack brinjal. Among them, shoot and fruit borer (*Leucinodes orbonalis*), whitefly (*Bemisia tabaci*), leafhopper (*Amarasca devastans*), epilachna beetle (*Henosepilachna vigintipunctata*), aphid (*Aphis gossypii*) and lace wing bug (*Urentius hystricellus*) are the major pests (Borkakati *et al.* 2019). Sucking pests of brinjal cause significant losses to crop by sucking the cell sap using their piercing and sucking mouth parts (Chatterjee *et al.* 2018).

Among sucking insect pests, whitefly ranks high in terms of devastation of numerous crops (Nauen *et al.* 2014). Whitefly is a multivoltine pest and no diapause stage is

reported so far. It produces 14–15 overlapping generations (Aneja 2000). In India, it reduces the yield of brinjal by 70–92% (Omprakash and Raju 2014). Various factors are responsible for the increasing trend of this pest on brinjal including the excessive use of insecticides, the eradication of natural enemies, plant growth due to insecticide application, translaminar action of insecticides, and variations in the nutrient content of the plant after insecticide application.

Translaminar action represents the chemical movement from one leaf face to the other. A number of processes are required for the expression of translaminar activity, such as dissolution, partitioning from the cuticle of leaf surface and later into the apoplast of leaf, diffusion via the mesophyll, and buildup of enough titer on the leaf's opposite side to escape the insect attack (Trapp 2004, Wang and Liu 2007, Zabkiewicz 2007). Translaminar absorption make the active ingredient available to insect pests feeding on the opposite or untreated leaf surface. This provides residual activity against certain insects. Continuous application of translaminar pesticides may have detrimental effects, including the quick emergence of tolerance or resistance, the creation of resistant genotypes, and resurgence of insect pests among those exposed. Probably, the pest outbreaks due to insecticides is the least studied aspect in *B. tabaci*. Hence, present study

¹Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. *Corresponding author email: neerudumra23@gmail.com

is devised to check the translaminar action of different group of insecticides.

MATERIALS AND METHODS

The present study was carried out at the research farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana during 2019 and 2020 to investigate translaminar action of insecticides on whitefly, *Bemisia tabaci* (Gennadius) in Hisar Shyamal variety of brinjal under screenhouse conditions.

Raising of test plants: The seedlings of the brinjal variety Hisar Shyamal were purchased from the nursery of vegetable science at Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana). One seedling was planted in each pot (30 cm × 23 cm). These pots were placed in a screenhouse which was free from whiteflies (mesh size: 12.5 mm × 3 mm). Whitefly infestation was protected by spraying screenhouse's walls, ceiling, and floor with formaline. The different insecticides at various doses were employed in the experiment namely, T₁, diafenthiuron 50% WP 150 g a.i./ha; T₂, diafenthiuron 50% WP 210 g a.i./ha; T₃, diafenthiuron 50% WP 300 g a.i./ha; T₄, fenpropathrin 30% EC 50 g a.i./ha; T₅, fenpropathrin 30% EC 70 g a.i./ha; T₆, fenpropathrin 30% EC 100 g a.i./ha; T₇, thiamethoxam 25% WG 25 g a.i./ha; T₈, thiamethoxam 25% WG 35 g a.i./ha; T₉, thiamethoxam 25% WG 50 g a.i./ha; T₁₀, deltamethrin 2.8% EC 7.5 g a.i./ha; T₁₁, deltamethrin 2.8% EC 10.5 g a.i./ha; T₁₂, deltamethrin 2.8% EC 15 g a.i./ha and; T₁₃, control. Using a pneumatic hand sprayer, pesticides were applied to the upper leaf surface. The plants were separated into five sets when they were 40 days old. One spray was applied to the first set, two sprays were applied to the second set, three sprays were applied to the third set, four sprays were applied to the fourth set, and five sprays were used to the fifth set. Seven days were passed between each successive spray. We took increasing number of sprays as the objective of the research was to check the threshold point beyond which mortality of whiteflies starts to decrease. The sprayed plants in each trial were taken out for further study. Subsequent sprays were spaced apart by seven days. The sprayed plants in each trial were taken out for further study.

Raising of *Bemisia tabaci* colony: The brinjal variety Hisar Shyamal plants were used to maintain the *B. tabaci* colony in a separate screenhouse. To begin the culture, adults of whitefly were collected from the field with an aspirator (30 cm) and released onto untreated brinjal plants kept within the screenhouse. New plants were regularly added to the existing ones and the F₁ generation of whitefly adults was used to maintain thriving whitefly colonies.

Leaf cages: The leaf cages were used in the experiment to prevent the vaporisation of insecticides. The cylindrical leaf cage was created by making a hole in the bottom of a cylindrical transparent plastic container. The glass was covered on the top with muslin fabric impregnated with fevicol to allow for ventilation, and a hole on the bottom side was sealed off with a cotton swab to allow

the whitefly nymphs to enter the cage.

Translaminar effect: The method given by De Cock *et al.* (1990), with a few minor modifications, was used to study the translaminar effect of numerous insecticidal sprays on the whitefly. They coated the upper side with a polyethylene stretch film and a sealed glass funnel with a floris trap was used instead of the leaf cages to prevent vapour pressure effect. The brinjal leaves infested with first instar nymphs of whitefly on lower surface were treated at the upper surface of leaf with different doses of insecticide using pneumatic sprayer. In case of control leaves, they were treated with water. There were three replications of each treatment and each treatment was having 30 nymphs. The mortality of first instar nymphs of *B. tabaci* was recorded by identifying the survival of red-eyed nymphs (pseudopupae/fourth instar nymphs). While surviving immatures had transformed into red-eyed nymphs (fourth instar/pseudopupal stage), dead nymphs remained attached to the leaves and could be easily distinguished by pricking.

Data analysis: A two-way ANOVA was performed to check the percentage mortality of *B. tabaci* nymphs after confirming normality with the Levene test in the IBM SPSS Statistic 23 Software. Posthoc comparison separated different treatment means by using Duncan's (1955) multiple range. Mean data on nymphal mortality was analysed with completely random design (CRD).

RESULTS AND DISCUSSION

In an experiment conducted in 2019, the upper surface of brinjal leaves treated with various pesticide concentrations had first instar *B. tabaci* nymphs on the bottom surface. The first instar nymph mortality percentage was reported. The translaminar impact of various treatments and spraying rates on the mortality of *B. tabaci* nymphs was examined using a two-way ANOVA. Data were gathered in August 2019 and August 2020 for two different time periods. According to a two-way ANOVA, the number of sprays and the various treatments had statistically significant interaction effects in August 2019 [$F(194, 48) = 24.91, P = 0.000$]. After different sprays, considerable translaminar effect of thiamethoxam 25% WG was observed (Table 1). After one spray, maximum translaminar effect was observed in highest dose of thiamethoxam 25% WG, i.e. T₉ followed by T₈ with 40.63 and 30.72% mean mortality of first instar nymphs of *B. tabaci*, respectively. The translaminar effect was not observed in T₁₂ because there was not any mortality of first instar nymph. Similar trend of results were followed after two, three, four and five sprays except, after four sprays, T₁₁ did not show any translaminar activity. Overall table revealed that considerable translaminar effect of T₉ after five sprays with 55.73% nymphal mortality while, T₁₂ showed no translaminar action after five sprays. According to pooled mean of data, maximum translaminar impact was recorded in T₉ and T₈ treated plants with mean mortality of first instar nymphs of 50.26% and 44.75%, respectively. The minimum translaminar effect was observed in T₁₂ and T₁₁ with 1.26 and 1.62% mortality of first instar nymph of *B.*

tabaci. Translaminar effect of diafenthiuron 50% WP and fenpropathrin 30% EC was at par with each other. Simple main effects study demonstrated that the nymph mortality was statistically affected by the various treatments ($P=0.000$). Again the simple main effect analysis showed that the number of sprays had a statistically significant impact on the mortality of nymphs ($P=0.000$).

Similar to 2019, a two-way ANOVA showed a statistically significant interaction between various treatments and the number of sprays in 2020 ($F(194, 48)=18.80$, $P=0.000$) (Table 2). There was significant simple main effects of different treatments on the nymphal mortality ($P=0.000$). However, the simple main effect of different sprays also had significant effect on nymphal mortality ($P=0.000$). After various sprays, the result trends remained largely the same as that of 2019 (Table 1). After one spray, the translaminar effect was found maximum in T_9 followed by T_8 with 43.17 and 35.61 mean per cent mortality of first instar nymphs of *B. tabaci*, respectively, which differ significantly from each other as well as other treatments.

Translaminar effect exhibited consistency in its trend in subsequent sprays. However, no translaminar effect was observed in deltamethrin 2.8% EC treated plant in all doses after one, four and five sprays.

On the contrary, thiamethoxam 25% WG exhibited maximum translaminar effect (55.63%) at 50 g a.i./ha, i.e. T_9 after five sprays and T_{12} exhibited no nymphal mortality hence no translaminar activity. T_1 , T_3 , T_4 and T_6 had moderate translaminar effect on whitefly and were at par with each other. Hence it can be concluded that thiamethoxam 25% WG treated plant had appreciable translaminar effect with considerable nymphal mortality and deltamethrin 2.8% EC treated plant had no translaminar effect. Translaminar effect of diafenthiuron 50% WP and fenpropathrin 30% EC was moderate. However, nymphal mortality is low in sub-lethal doses of insecticides as compared to lethal doses. These experiments verified that translaminar mobility is a characteristic shared by several substances with insecticidal effect.

Our findings concur with those made by Kaur (2007) and

Table 1 Translaminar effect of different insecticidal treatments on brinjal (2019)

Treatment	Mean Mortality (%) (Mean $\pm$ SE)											
	2019					Pooled mean	2020					Pooled mean
	1 spray	2 sprays	3 sprays	4 sprays	5 sprays		1 spray	2 sprays	3 sprays	4 sprays	5 sprays	
T_1	10.17 $\pm$ 0.33g	16.14 $\pm$ 0.54g	19.21 $\pm$ 0.62h	22.48 $\pm$ 0.77i	17.14 $\pm$ 0.60d	17.02 $\pm$ 0.62	15.17 $\pm$ 0.49g	11.23 $\pm$ 0.37g	15.23 $\pm$ 0.50h	17.41 $\pm$ 0.60i	19.48 $\pm$ 0.68d	15.70 $\pm$ 0.56
T_2	7.23 $\pm$ 0.24h	14.24 $\pm$ 0.46l	22.25 $\pm$ 0.73b	25.43 $\pm$ 0.83q	27.41 $\pm$ 0.90l	19.71 $\pm$ 0.71	9.17 $\pm$ 0.31h	12.14 $\pm$ 0.39l	18.15 $\pm$ 0.60b	20.23 $\pm$ 0.66q	23.61 $\pm$ 0.77i	16.66 $\pm$ 0.60
T_3	5.00 $\pm$ 0.17f	15.31 $\pm$ 0.53p	25.72 $\pm$ 0.81p	18.23 $\pm$ 0.59f	27.85 $\pm$ 0.90o	18.82 $\pm$ 2.16	8.03 $\pm$ 0.28f	15.28 $\pm$ 0.53p	20.27 $\pm$ 0.64p	22.15 $\pm$ 0.72f	25.31 $\pm$ 0.82o	18.20 $\pm$ 0.63
T_4	10.70 $\pm$ 0.49k	18.42 $\pm$ 0.86j	15.62 $\pm$ 0.70w	20.50 $\pm$ 0.96u	26.14 $\pm$ 1.25j	18.27 $\pm$ 0.91	5.87 $\pm$ 0.29k	16.14 $\pm$ 0.75j	22.51 $\pm$ 1.13w	20.13 $\pm$ 0.95u	18.91 $\pm$ 0.90j	16.71 $\pm$ 0.84
T_5	9.21 $\pm$ 0.25i	15.32 $\pm$ 0.43q	20.00 $\pm$ 0.57v	28.65 $\pm$ 0.79r	25.00 $\pm$ 0.70y	19.63 $\pm$ 0.59	10.21 $\pm$ 0.28i	19.48 $\pm$ 0.55q	22.34 $\pm$ 0.63v	23.71 $\pm$ 0.66r	24.78 $\pm$ 0.70y	20.10 $\pm$ 0.61
T_6	8.57 $\pm$ 0.35j	14.13 $\pm$ 0.59q	20.14 $\pm$ 0.79r	25.30 $\pm$ 0.98h	27.45 $\pm$ 1.09r	19.11 $\pm$ 0.67	6.32 $\pm$ 0.26j	14.21 $\pm$ 0.59q	25.00 $\pm$ 0.98r	24.18 $\pm$ 0.94h	27.15 $\pm$ 1.07r	19.37 $\pm$ 0.68
T_7	20.85 $\pm$ 0.31d	25.12 $\pm$ 0.35d	29.23 $\pm$ 0.44q	34.14 $\pm$ 0.49o	40.14 $\pm$ 0.55d	29.89 $\pm$ 0.45	18.50 $\pm$ 0.28d	21.76 $\pm$ 0.33d	32.13 $\pm$ 0.49q	39.14 $\pm$ 0.59o	25.48 $\pm$ 0.38d	27.40 $\pm$ 0.41
T_8	30.72 $\pm$ 1.23l	45.29 $\pm$ 1.94r	47.17 $\pm$ 1.99b	49.37 $\pm$ 2.04f	51.23 $\pm$ 2.18u	44.75 $\pm$ 2.01	35.61 $\pm$ 1.60l	44.63 $\pm$ 1.91r	45.23 $\pm$ 1.90b	53.51 $\pm$ 2.21f	49.57 $\pm$ 2.11u	45.71 $\pm$ 2.06
T_9	40.63 $\pm$ 1.24l	49.83 $\pm$ 1.54s	51.32 $\pm$ 1.60g	53.82 $\pm$ 1.65x	55.73 $\pm$ 1.67g	50.26 $\pm$ 1.81	43.17 $\pm$ 1.41l	51.29 $\pm$ 1.68s	52.04 $\pm$ 1.70g	53.75 $\pm$ 1.76x	55.63 $\pm$ 1.67g	51.17 $\pm$ 1.84
T_{10}	0.00 $\pm$ 0.00e	8.13 $\pm$ 0.21o	0.00 $\pm$ 0.00f	2.13 $\pm$ 0.05i	0.00 $\pm$ 0.00r	2.05 $\pm$ 0.85	0.00 $\pm$ 0.00e	0.00 $\pm$ 0.00e	2.75 $\pm$ 0.07f	0.00 $\pm$ 0.00i	0.00 $\pm$ 0.00r	0.55 $\pm$ 0.01
T_{11}	3.14 $\pm$ 0.05d	0.00 $\pm$ 0.00m	5.00 $\pm$ 0.08u	0.00 $\pm$ 0.00b	0.00 $\pm$ 0.00j	1.62 $\pm$ 0.55	0.00 $\pm$ 0.00d	3.16 $\pm$ 0.05m	0.00 $\pm$ 0.00u	0.00 $\pm$ 0.00b	0.00 $\pm$ 0.00j	0.63 $\pm$ 0.00
T_{12}	0.00 $\pm$ 0.00e	0.00 $\pm$ 0.00n	0.00 $\pm$ 0.00l	6.32 $\pm$ 0.15u	0.00 $\pm$ 0.00u	1.26 $\pm$ 0.68	0.00 $\pm$ 0.00e	0.00 $\pm$ 0.00n	0.00 $\pm$ 0.00l	0.00 $\pm$ 0.00u	0.00 $\pm$ 0.00u	0.00 $\pm$ 0.00
T_{13}	4.32 $\pm$ 0.11b	3.00 $\pm$ 0.07h	2.12 $\pm$ 0.05t	0.00 $\pm$ 0.00r	0.00 $\pm$ 0.00d	1.88 $\pm$ 0.45	2.13 $\pm$ 0.05b	0.00 $\pm$ 0.00h	0.00 $\pm$ 0.00t	3.14 $\pm$ 0.08r	0.00 $\pm$ 0.00d	1.05 $\pm$ 0.02

The data represent mean $\pm$ standard error of the mean ($n=3$). Values indicated by same alphabetic letter showed no statistically significant difference between values ($P>0.05$, two-way ANOVA followed by Bonferroni test). Treatment details are given under Materials and Methods.

Table 2 Results of two-way analysis of variance (ANOVA) of treatments and number of sprays during 2019 and 2020

	Source	F	P value	df	R ²
2019	Treatments	1497.15	0.00	12	0.994
	Number of sprays	327.61	0.00	4	
	Treatments × Number of sprays	24.91	0.00	48	
2020	Treatments	1640.03	0.00	12	0.994
	Number of sprays	252.43	0.00	4	
	Treatments × Number of sprays	18.80	0.00	48	

Shuchita (2005). They observed appreciable translaminar effect of novaluron 10 EC and diafenthiuron 50% WP with 30.40 and 26.72% mortality of first instar nymphs of *B. tabaci* in LC₃₀ treatments and 48.40 and 39.11% mortality in LC₅₀ treatments, respectively upon treatment of upper surface of cotton leaves. Barry *et al.* (2015) reported pronounced translaminar activity of cyantraniliprole against *P. xylostella*. In study, upper surface of cabbage leaves having population of *P. xylostella* nymphs was treated with cyantraniliprole (10 OD) + 0.5% MSO (adjuvant methylated seed oil) and observed pronounced translaminar activity (94%) having mesophyll and lower epidermis punctured.

While previous scholars found significant translaminar impact of different insecticides mostly on pyriproxyfen (Ishaaya *et al.* 1994, Ishaaya and Horowitz 1995, Valle *et al.* 2002), this study adds to the existing literature by examining the impact of different new insecticides such as diafenthiuron, fenpropathrin, deltamethrin etc. on nymphal mortality rate on *B. tabaci* in brinjal plant (Fig 1). These insecticides were used because they have been approved and recommended by CIBRC against whitefly on brinjal. Authors found limited literature that has tested the impact of these insecticides on mortality rate of *B. tabaci*. Examining the impact of these insecticides would benefit agricultural

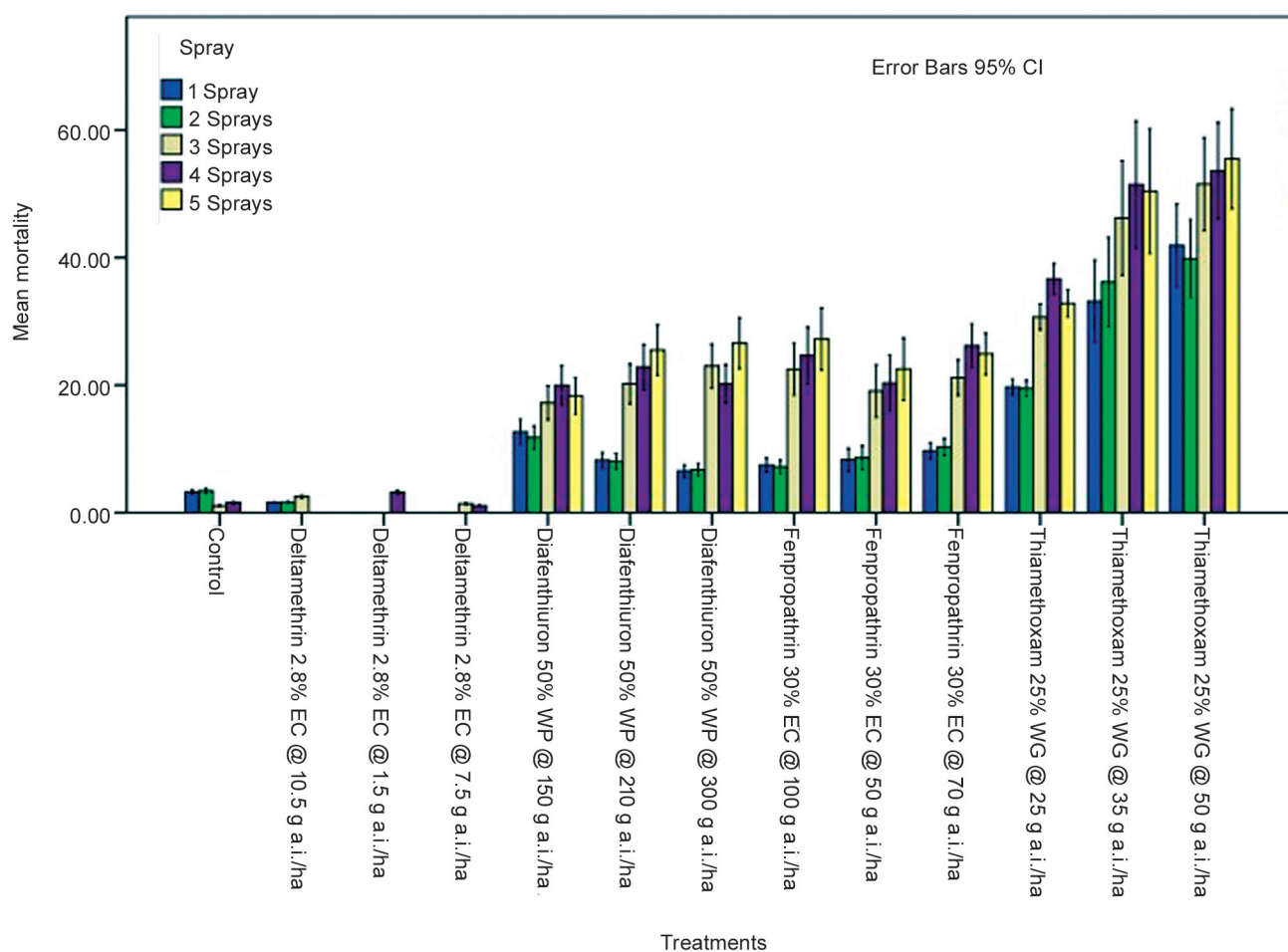


Fig 1 Average (mean $\pm$ standard error) of nymphal mortality percentage of *Bemisia tabaci* on treated brinjal leaves after different sprays.

practitioners and farmers especially on brinjal plant. Through this study, farmers and practitioners would know translaminar effect of these insecticides on brinjal plant and hence it would help them to improve quality and productivity of brinjal plant. Finally this study recommends farmers and practitioners to apply specific doses of insecticides with significant translaminar effects.

Limitations and future research: This study was conducted in controlled conditions. Future scholars can perform the study in field experiment and enhance the understanding of other exogenous variables impact on the mortality of whiteflies. Further studies are needed to understand the physiology of changes that occur in the host plant due to application of insecticides and how they are going to influence the suitability of the brinjal host for feeding, breeding and shelter niches for *B. tabaci*. This type of study will also be replicated in other crops like cotton, tomato, okra etc. against *B. tabaci*.

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