Indian Journal of Entomology Online published Ref. No. e23247 DoI. No.: 10.55446/IJE.2023.1247

INCIDENCE OF SAPOTA SEED BORER *TRYMALITIS MARGARIAS* MEYRICK AND ITS MANAGEMENT

Bharati Jambunatha Patil[1]* and Suchithra Kumari M H[1]

[1]Department of Entomology, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga 577204, Karnataka, India
*Email: bharathipatil913@gmail.com (corresponding author): ORCID ID 0000-0003-2547-3480

ABSTRACT

A study on the incidence and management of sapota seed borer *Trymalitis margarias* Meyrick was conducted from 2019 to 2020 in Mudigere. The varietal screening experiment revealed that PKM-1 was the least susceptible variety with 4.58% fruit damage followed by DSH-1 (9.79%) while Kalipatti was found to be highly susceptible (18.76%). The highest parasitisation by the larval parasitoid, *Bracon* sp. was seen in Kalipatti i.e., 28.13% while the least was observed in PKM-1 (7.29%). Among the insecticides screened against *T. margarias* from two sprays, profenophos 50EC (0.13 larvae/ fruit and 9.72% fruit damage) and novaluron 10EC (0.19 larvae/ fruit and 13.43% fruit damage) performed very well over standard check deltamethrin 2.8EC (0.3 larvae/ fruit and 22.22% fruit damage) in minimizing the infestation. Further, the highest fruit yield and the cost-benefit ratios were documented in novaluron 10EC (7.37 t/ ha and 1: 2.96).

Key words: *Trymalitis margarias*, sapota varieties, PKM-1, DSH-1 Kalipatti, fruit damage, *T. margarias* larvae, larval parasitoid, *Bracon* sp., insecticides, management, Mudigere, yield, cost economics,

Sapota, *Manilkara zapota* (L.) being an evergreen hardy fruit crop is less often attacked by insect pests but nowadays pest status is changing mainly due to the lack of management practices and extensive cultivation of Kalipatti and Cricket Ball varieties over a larger area. A total of 33 insect and non-insect pests are reported on sapota in India (Bisane et al., 2018). Of these, *Trymalitis margarias* Meyrick is a monophagous, microlepidoteran pest which has assumed the status of major pest. It attacks the immature fruits and feeds exclusively on the endosperm of the seed. The full grown larvae exits the fruit by making a small exit hole on the fruit and pupates in the leaf folds. The exit hole serves as an entry point for several saprophytic microorganisms and insects, so the fruit quality and market value are reduced and become unfit for human consumption. The activity of *T. margarias* was noticed throughout the year but peak infestation was seen during March while the lowest activity was observed in September. The loss due to this pest was 27.05% in Kalipatti and 14.88% in Cricket Ball variety in Mudigere (Patil et al., 2020; and Bisane and Naik 2021a). The loss caused by *T. margarias* was estimated as 40 to 90% in Maharashtra (Patel, 2002). In sapota, the farmer cannot estimate the damage in general and of *T. margarias* in particular, mainly because of its continuous flowering and fruiting, long duration between flower bud initiation to fruit maturity coupled with its concealed feeding behaviour. There are no insecticide recommendations for this pest in CIBR&C and only deltamethrin 10%EC was recommended under the package of practices in Karnataka (Anonymous, 2020a). Still there is a scope for selecting the best insecticide or combination products for managing this pest. The present study has been done with the objectives like screening varieties of sapota for their resistance against *T. margarias*, recording the activity of natural enemies on it, and also studying the efficacy of insecticides.

MATERIALS AND METHODS

The study on varietal screening, natural enemies and management was carried out in the Entomology Department, College of Horticulture and Krishi Viynana Kendra, Mudigere, Karnataka, India during 2019-2020. Mudigere is situated at 982 m above the mean sea level (MSL: 13°7'29" N; 75°37' E) and is located in the agroclimatic region VI, zone 9 (hill zone) of Karnataka. The varietal screening was conducted in the sapota blocks maintained at the Horticulture College, Mudigere from July 2019 to June 2020. The experiment was set up under Randomized Complete Block Design (RCBD) with five treatments viz., Kalipatti, Cricket Ball, PKM-1, DSH-1 and DSH-2 and four replications. The trees of these varieties were 14 years old that are planted at 30 × 30 feet spacing. No insecticidal sprays were given so as to retain the pest load. Four trees of each variety were selected randomly and tagged for recording observations. In each replication, 25 medium-sized immature fruits were randomly collected at monthly intervals from all four directions (three fruits from each direction) manually or by using a venture fruit plucker. The total number of fruits in a tree was determined by working out the relative canopy area or canopy spread of the marked trees as per the methodology given by Das (1986). Fruit damage was assessed based on the observation as explained under results and discussion. The density of fruits was counted manually by placing the square structure of one m^2 dimension made of wooden sticks (1 m length) tied to a long wooden pole in four directions on the tree, and the fruits number was counted.

The harvested fruits were also observed for parasitization by the larval parasitoids. The emerged parasitoids were collected, labelled with pertinent details and were sent for identification to the ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bengaluru. The insecticides screening experiment was carried out in the sapota block i.e., Kalipatti variety of 35 years old with 30 × 30 feet spacing at KVK, Mudigere from December 2019 to March 2020. A RCBC design with ten treatments and three replications was adopted. Each tree represented one replication. The *T. margarias* infestation was observed in an adjacent sapota plot and when the infestation reached 5%, the treatments imposition was done. Therefore, the first insecticide spray was given in December 2019 and the second during the last weeks of February 2020 using AMP- 768PRO® portable power sprayer in the early morning hours. The pretreatment observations were recorded on the day of sprays and the post treatment observations were recorded during 3, 5 and 10 days after spray (DAS). The sampling method was same as varietal screening experiment. The % fruit damage was computed as per Bisane et al. (2019). Reduction in the larval incidence and fruit damage was calculated using the formula given by Henderson and Tilton (1955). The mature fruits were harvested and weighed in individual replications and treatments separately and yield/ tree was recorded to estimate the yield/ hectare and economics was worked out as per Suchithrakumari et al. (2018). One-way ANOVA of the number of larvae of *T. margarias*, fruit and seed damage was done using SPSS software v.21 and Microsoft Excel.

RESULTS AND DISCUSSION

Present study focused on varietal screening to arrive at proper information on their performance against *T. margarias* infestation. The sampled fruits were cut open to observe the infestation by recording the number of larvae/ fruit, larval galleries, tunnelling of fruit and seeds; and presence of exit holes on the seeds and fruits. The fruit damage and seed damage were calculated as per Bisane et al. (2019). The last instar *T. margarias* larvae were allowed to pupate in the provided sapota leaves and the emerged adults were pinned and labelled for reference (Fig. 1-3 a-d). Based on these observation, it was evident that none of the variety was found completely resistant. Although, PKM-1 was the least susceptible variety and recorded significantly the lowest larval density (0.45/ fruit), fruit (4.58%) and seed damage (9.55%). A significantly higher infestation was noticed in Kalipatti with 0.77 larvae/ fruit, 18.76%

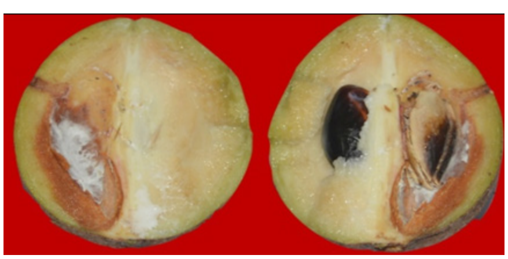

Fig. 1. *T. margarias* damage on fruit

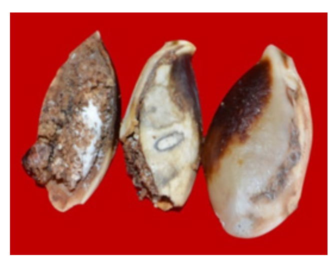

Fig. 2. *T. margarias* damage on seeds

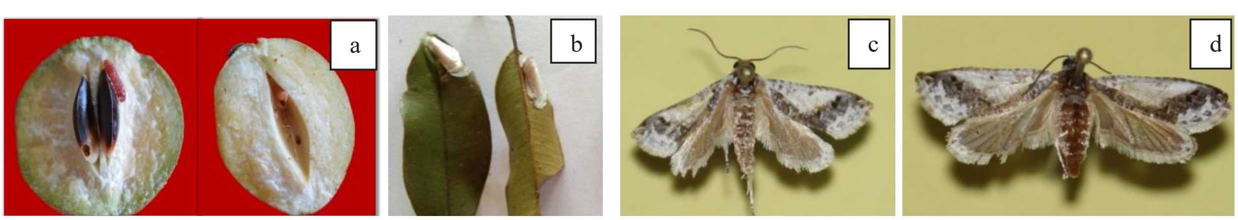

Fig. 3. a. *T. margarias* larvae; b. *T. margarias* pupa; c. Female *T. margarias*; d. Male *T. margarias*

fruit damage and 31.25% seed damage and was found to be a highly susceptible (Table 1). This might be due to variations in the biochemical constituents viz., total soluble solids (TSS) and total sugars and morphological characteristics like the surface thickness of the fruits. Karthik (2019) found a significant positive correlation between fruit surface thickness and *T. margarias* damage but between TSS, and total sugar it was a non-significant positive correlation. Similar findings were recorded by Patel et al. (2020), Bisane and Naik (2016) and Bisane (2016) who found that Kalipatti, DHS-2 and Cricket ball had a higher infestation of *T. margarias* while moderate damage was noted in DHS-1, PKM-1 and PKM-2. The findings are in accordance with Patel and Bisane (2020) where, Kalipatti variety recorded significantly more infestation than DSH-2 and Cricket Ball. Bisane and Naik (2021b) evaluated 23 varieties against *T. margarias* and revealed that Kirthibarthi was more susceptible than Kalipatti variety; and while PKM-3 and PKM-4 were found to be less susceptible; and DSH-2 and CO-2 were found more vulnerable. The parasitoid specimens could not be identified at the species level- it was identified as *Bracon* sp. (Hymenoptera: Braconidae) by the ICAR-NBAIR, Bengaluru. The male and female wasps can be identified based on the presence of an ovipositor (Fig. 4 a, b). The parasitized larvae became soft, mummified and turned black color at the later stages (Fig. 4 c, d). Table 1 indicates that the significantly highest parasitisation was noticed in Kalipatti i.e., 28.13% while the lowest parasitisation was documented in PKM-1 i.e., 7.29%. Kanade (2005) reported that *T. margarias* larvae were found parasitized by a hymenopteran parasitoid. Makwana (2002) reported that larvae were parasitized by two larval and one pupal unidentified hymenopterous parasitoid.

In two insecticidal sprays, the pre-treatment observations showed non-significant differences. In all the treatments, larval density and fruit damage decreased except in control during 3 and 5 DAS but showed an increasing trend during 10 DAS. After the

Table 1. Seed borer *T. margarias* infestation and its parasitoid activity in varieties of sapota

S. No.	Treatment (Variety)	Larvae (No./ fruit)	Damage (%)		Parasitization (%)
			Fruit	Seed	
1	Kalipatti	0.77 (0.87)^{*c}	18.76 (35.48)^{**d}	31.25 (33.74)^{**b}	28.13 (31.94)^{**c}
2	Cricket Ball	0.68 (0.83)^{bc}	12.92 (21.04)^{bc}	25.09 (29.81)^{b}	21.73 (27.24)^{bc}
3	PKM-1	0.45 (0.66)^{a}	4.58 (11.63)^{a}	9.55 (16.66)^{a}	7.29 (11.20)^{a}
4	DSH-1	0.55 (0.74)^{ab}	9.79 (18.08)^{b}	20.40 (26.22)^{b}	10.90 (19.26)^{ab}
5	DSH-2	0.65 (0.81)^{bc}	10.84 (18.94)^{bc}	22.48 (27.41)^{b}	14.58 (22.40)^{bc}
SEm±		0.04	1.82	3.10	3.12
CD (p=0.05)		0.12	5.65	9.33	9.73
CV%		10.08	17.25	22.40	27.86
F value		4.15	23.54	4.48	3.60

*Figures in parentheses angular $\sqrt{X + 0.5}$ transformed; **Figures in parentheses transformed; Mean values followed by the same letter within and between columns not significantly different ($p \leq 0.05$)

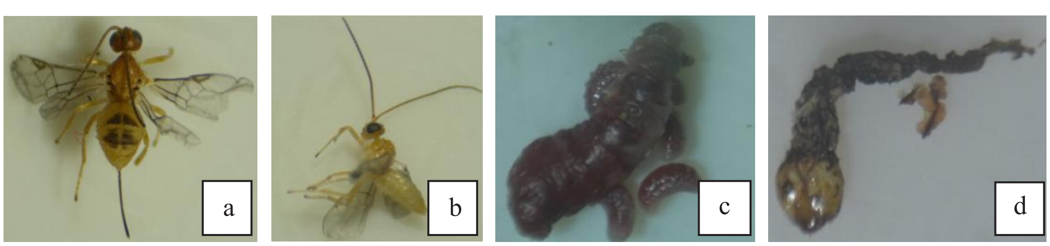

Fig. 4. a. Female *Bracon* sp; b. Male *Bracon* sp; c. Grubs of *Bracon* sp. feeding on *T. margarias* larvae; d. Parasitized *T. margarias* larvae

first spray, the mean of 3, 5 and 10 DAS indicated that profenophos 50EC at 1.5 ml/ l (0.11 larvae/ fruit and 11.11% fruit damage) and novaluron 10EC at 0.5 ml/ l (0.17 larvae/ fruit and 15.74% fruit damage) was equally effective and exhibited significant superiority over standard check deltamethrin 2.8EC at 0.5 ml/ l (0.27 larvae/ fruit and 25% fruit damage) and other treatments concerning the minimum infestation by *T. margarias* (Table 2); also highest reduction in larvae and fruit damage in profenophos 50EC at 1.5 ml/ l (86.14% and 79.83%, respectively). After the second insecticidal spray, a similar trend was observed in the efficacy (Table 3).

Table 4 depicts the pooled data on first and second sprays. The order of efficacy of insecticides was profenophos 50EC > novaluron 10EC > indoxacarb 14.5SC > deltamethrin 2.8EC > thiodicarb 75WP = chlorantraniliprole 18.5SC > spinosad 45SC > flubendiamide 39.35SC > azadirachtin 10,000 ppm for reduction in larvae over control. The highest efficacy in profenophos 50EC might be because of its potent ovicidal and larvicidal action coupled with a quick knockdown effect and offers long-term protection due to its persistency (Preetha et al., 2007). Novaluron is an insect growth regulator (IGR) having a unique mode of action of inhibiting chitin synthesis and targetting larval insect stages at the time of molting (abortive molting) and also has prolonged persistence, providing long-lasting control (Cutler and Scott-Dupree, 2007). The present findings agree with those of Shinde et al. (2014), on profenophos 50EC. Consistent results were obtained even after three sprays of profenophos 0.075% by minimizing the *T. margarias* damage at Gandevi (Gujarat) and Palghar (Maharashtra) and were found superior (Bisane et al., 2019). The present findings partially corroborates with Khambu and Bisane (2015) wherein profenophos 50EC was found moderately effective. The results are also in line with Bisane et al. (2022) where, profenophos 50EC reduced the fruit damage significantly profenophos 50EC. The present findings are in contradictory with Shilpa et al. (2023), who reported that deltamethrin 2.8EC, flubendiamide 39.35SC and emamectin benzoate 5SG were found to be statistically onpar and were found to be the most promising treatments against *T. margarias* infestation.

A significant difference existed among the treatments concerning yield. The highest fruit yield was obtained in the trees treated with novaluron 10EC at 0.5 ml/ l with 7.37 t/ha (49.10% increase over control) followed by profenophos 50EC at 1.5 ml/ l (7.14 t/ ha) (47.45% increase over control). The reason for this can be ascribed to a higher reduction in infestation associated with its good phytotonic effect on trees (Anonymous, 2020b). The benefit-cost analysis of insecticides is depicted in Table 4. Novaluron 10EC at 0.5 ml/ l was found to be a highly profitable treatment over standard check deltamethrin 2.8EC and other treatments with the highest benefit-cost ratio (B:C) of 1:2.96 followed by profenophos 50EC at 1.5 ml/ l (1:2.91). Similar observations on fruit yield were documeted by Bisane et al. (2022). Our findings are in partial agreement with Bisane et al. (2017), where obtained fruit yield with profenophos 50EC followed by novaluron 10EC. Vijayaraghavendra and Basavanagoud (2017) also observed a statistical similarity between the treatments towards the fruit yield/ ha; highest yield was registered by spinosad 45SC followed by profenophos 50EC. The results are in contradictory with Shilpa et al. (2023) where maximum fruit yield was documented in deltamethrin 2.8EC. Contrastingly, Khambhu and Bisane (2015) stated that there was no significant difference between treatments for the marketable fruit yield/tree. Still, the highest fruit yield was recorded in emamectin benzoate 5SG followed by thiodicarb 75WP. Suchithrakumari et al. (2018) found that the highest profitable treatment was flubendiamide 480SC with the highest gross returns, net returns, and benefit-cost ratio.

Varietal preference for feeding by the *T. margarias* was observed in the study where in Kalipatti variety was more preferred over Cricket Ball and others. *T. margarias* was found to be parasitized by a larval parasitoid, *Bracon* sp. with the highest parasitisation in Kalipatti than Cricket Ball. Profenophos 50EC and novaluron 10EC were the most promising insecticides compared to standard check deltamethrin 2.8EC in managing this pest while the highest fruit yield was obtained in novaluron 10EC sprayed plots. Thus on an economic basis, novaluron 10EC was the most profitable treatment followed by profenophos 50EC.

ACKNOWLEDGEMENTS

The authors thank the Dean (Hort.), College of Horticulture, Mudigere, Sr. Scientist and Head, KVK, Mudigere for providing the field to conduct research.

FINANCIAL SUPPORT

This work was financially supported by the Directorate of Research, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga under the SRPF project.

Table 2. Efficacy of insecticides against *T. margarias* after first spray (December 2019)

Sl. No.	Treatment	Dosage (ml or g/ ha)	The mean number of larvae/ fruit*					% fruit damage**				
			BS	3 DAS	5 DAS	10 DAS	Mean	BS	3 DAS	5 DAS	10 DAS	Mean
1	Deltamethrin 2.8EC	300	0.42 (0.64)	0.28 (0.53)^{bc}	0.25 (0.50)^{cd}	0.28 (0.53)^{bcd}	0.27 (0.52)^{bc}	36.11 (36.75)	25.00 (30.00)^{bcd}	22.22 (28.03)^{cd}	27.78 (31.75)^{cde}	25.00 (29.98)^{cd}
2	Flubendiamide 39.35SC	120	0.50 (0.70)	0.42 (0.64)^{de}	0.36 (0.59)^{de}	0.39 (0.62)^{cd}	0.39 (0.62)^{de}	41.67 (40.16)	38.89 (38.56)^{ef}	30.56 (33.40)^{de}	36.11 (36.91)^{ef}	35.19 (36.36)^{ef}
3	Spinosad 45SC	180	0.53 (0.73)	0.36 (0.60)^{cd}	0.31 (0.55)^{de}	0.33 (0.57)^{cd}	0.33 (0.58)^{cd}	38.89 (38.56)	33.33 (35.16)^{df}	27.78 (31.75)^{de}	30.56 (33.51)^{de}	30.56 (33.54)^{de}
4	Chlorantraniliprole 18.5SC	180	0.44 (0.67)	0.31 (0.55)^{cd}	0.25 (0.50)^{cd}	0.31 (0.55)^{bcd}	0.28 (0.53)^{bc}	36.11 (36.91)	30.56 (33.51)^{de}	22.22 (28.03)^{cd}	25.00 (29.79)^{bcd}	25.93 (30.56)^{cd}
5	Azadirachtin 10,000 ppm	1200	0.50 (0.69)	0.50 (0.71)^{e}	0.42 (0.64)^{e}	0.47 (0.68)^{d}	0.46 (0.68)^{e}	47.22 (43.35)	41.67 (40.16)^{f}	36.11 (36.91)^{e}	44.44 (41.75)^{f}	40.74 (39.65)^{f}
6	Profenophos 50EC	900	0.42 (0.64)	0.14 (0.37)^{a}	0.08 (0.29)^{a}	0.11 (0.33)^{a}	0.11 (0.33)^{a}	38.89 (38.56)	13.89 (21.66)^{a}	8.33 (16.78)^{a}	11.11 (19.22)^{a}	11.11 (19.38)^{a}
7	Novaluron 10 EC	300	0.33 (0.57)	0.19 (0.44)^{ab}	0.14 (0.37)^{ab}	0.17 (0.40)^{ab}	0.17 (0.41)^{a}	36.11 (36.91)	19.44 (26.06)^{ab}	11.11 (19.22)^{ab}	16.67 (24.09)^{ab}	15.74 (23.24)^{a}
8	Indoxacarb 14.5SC	240	0.39 (0.62)	0.25 (0.50)^{bc}	0.17 (0.40)^{abc}	0.22 (0.47)^{abc}	0.21 (0.46)^{ab}	41.67 (40.20)	22.22 (28.03)^{bc}	16.67 (24.09)^{bc}	19.44 (26.06)^{bc}	19.44 (26.13)^{ab}
9	Thiodicarb 75WP	600	0.33 (0.57)	0.28 (0.53)^{bc}	0.22 (0.47)^{bcd}	0.25 (0.49)^{bc}	0.25 (0.50)^{b}	38.89 (38.56)	27.78 (31.75)^{cd}	19.44 (26.06)^{c}	22.22 (28.03)^{bcd}	23.15 (28.70)^{bc}
10	Control	-	0.61 (0.78)	0.94 (0.97)^{f}	1.17 (1.08)^{f}	1.42 (1.19)^{e}	1.19 (1.08)^{f}	44.44 (41.75)	55.56 (48.20)^{g}	61.11 (51.44)^{f}	72.22 (58.25)^{g}	62.96 (52.60)^{g}
$SE_m \pm$				0.04	0.04	0.05	0.02		1.80	2.01	2.19	1.23
CD at (p= 0.05)			NS	0.10	0.12	0.15	0.07	NS	5.34	5.97	6.50	3.66
CV%				10.50	13.01	14.76	7.06		9.35	11.77	11.51	6.67

Standard check: Deltamethrin 2.8 EC; *Values in the parentheses $\sqrt{X + 0.5}$ transformed; **Values in the parentheses angular transformed; Mean values followed by the same letter within a column are not significantly different ($p \leq 0.05$); NS: Non-Significant; BS: Before Spray; DAS: Days after spray.

Table 3. Efficacy of insecticides against *T. margarias* after second spray in February 2020

Sl. No.	Treatment	Dosage (ml or g/ ha)	The mean number of larvae/ fruit				Mean	% fruit damage**				Mean
			BS	3 DAS	5 DAS	10 DAS		BS	3DAS	5DAS	10 DAS	
1	Deltamethrin 2.8EC	300	0.58 (0.76)	0.36 $(0.60)^{bc}$	0.31 $(0.55)^{bcd}$	0.33 $(0.57)^{bcd}$	0.33 $(0.58)^{cde}$	38.89 (38.35)	19.44 $(26.06)^{bc}$	16.67 $(24.09)^{c}$	22.22 $(28.03)^{cd}$	19.44 $(26.13)^{b}$
2	Flubendiamide 39.35SC	120	0.61 (0.78)	0.47 $(0.68)^{cd}$	0.39 $(0.62)^{cd}$	0.50 $(0.70)^{d}$	0.45 $(0.67)^{ef}$	44.44 (41.75)	33.33 $(35.26)^{de}$	27.78 $(31.75)^{e}$	36.11 $(36.91)^{ef}$	32.41 $(34.67)^{d}$
3	Spinosad 45SC	180	0.64 (0.80)	0.44 $(0.66)^{cd}$	0.33 $(0.57)^{bcd}$	0.42 $(0.63)^{cde}$	0.40 $(0.63)^{de}$	41.67 (40.20)	27.78 $(31.75)^{d}$	22.22 $(28.03)^{de}$	30.56 $(33.51)^{de}$	26.85 $(31.16)^{c}$
4	Chlorantraniliprole 18.5SC	180	0.61 (0.78)	0.39 $(0.62)^{cd}$	0.31 $(0.55)^{bcd}$	0.38 $(0.60)^{bcd}$	0.36 $(0.60)^{cde}$	38.89 (38.56)	25.00 $(29.79)^{cd}$	19.44 $(26.06)^{cde}$	27.78 $(31.75)^{de}$	24.07 $(29.32)^{c}$
5	Azadirachtin 10,000 ppm	1200	0.58 (0.74)	0.53 $(0.73)^{d}$	0.47 $(0.68)^{d}$	0.58 $(0.76)^{e}$	0.53 $(0.73)^{f}$	47.22 (43.35)	41.67 $(40.16)^{e}$	41.67 $(40.20)^{f}$	44.44 $(41.80)^{f}$	40.74 $(39.65)^{e}$
6	Profenophos 50EC	900	0.58 (0.76)	0.19 $(0.44)^{a}$	0.11 $(0.33)^{a}$	0.17 $(0.40)^{a}$	0.16 $(0.39)^{a}$	36.11 (36.91)	11.11 $(19.22)^{a}$	5.56 $(11.19)^{a}$	8.33 $(16.78)^{a}$	8.33 $(16.63)^{a}$
7	Novaluron 10EC	300	0.42 (0.64)	0.25 $(0.50)^{ab}$	0.19 $(0.44)^{ab}$	0.21 $(0.45)^{ab}$	0.22 $(0.47)^{ab}$	33.33 (35.16)	13.89 $(21.66)^{ab}$	8.33 $(16.78)^{ab}$	11.11 $(19.22)^{ab}$	11.11 $(19.38)^{a}$
8	Indoxacarb 14.5SC	240	0.53 (0.72)	0.31 $(0.55)^{ab}$	0.25 $(0.50)^{bc}$	0.29 $(0.54)^{abc}$	0.28 $(0.53)^{bc}$	41.67 (40.20)	19.44 $(26.06)^{bc}$	16.67 $(24.09)^{cd}$	22.22 $(28.03)^{cd}$	19.44 $(26.13)^{b}$
9	Thiodicarb 75WP	600	0.56 (0.74)	0.36 $(0.60)^{bc}$	0.28 $(0.53)^{bc}$	0.33 $(0.57)^{bcd}$	0.32 $(0.57)^{cd}$	38.89 (38.56)	16.67 $(23.62)^{ab}$	13.89 $(21.66)^{bc}$	16.67 $(24.09)^{bc}$	15.74 $(23.36)^{b}$
10	Control	-	0.64 (0.80)	0.72 $(0.85)^{e}$	1.22 $(1.10)^{e}$	1.63 $(1.27)^{f}$	1.19 $(1.08)^{g}$	47.22 (43.40)	58.33 $(49.84)^{f}$	63.89 $(53.09)^{g}$	72.22 $(58.46)^{g}$	64.81 $(53.68)^{f}$
$SE_m \pm$				0.04	0.04	0.05	0.03		1.90	2.13	2.10	0.97
CD at 5%			NS	0.11	0.13	0.15	0.09	NS	5.61	6.34	6.00	2.87
CV%				10.02	12.88	13.02	8.42		10.76	13.50	10.98	5.58

Standard check: Deltamethrin 2.8EC; *Values in the parentheses are $\sqrt{X + 0.5}$ transformed; **Values in the parentheses angular transformed; Mean values followed by same letter within a column not significantly different ($p \leq 0.05$); NS: Non-Significant; BS: Before Spray; DAS: Days after spray

Table 4. Efficacy of insecticides against *T. margarias* and cost benefits (pooled)

Sl. No.	Treatment	Dosage (ml or g/ ha)	Number of larvae per fruit	% fruit damage	Yield/ ha		Cost of protection (Rs./ ha)	The total cost of production (Rs./ ha)	Gross returns (Rs./ ha)	Net returns (Rs./ ha)	BC ratio
					Tree (kg)	Hectare (t)					
1	Deltamethrin 2.8 EC	300	0.30 (0.55)^{cd}	22.22 (28.05)^{cd}	62.04	6.20	320.00	65,545.00	1,73,702.67	1,20,565.00	2.84
2	Flubendiamide 39.35 SC	120	0.42 (0.65)^{de}	33.80 (35.51)^{f}	49.43	4.94	1,970.00	63,415.00	1,38,394.67	74,979.67	2.18
3	Spinosad 45 SC	180	0.37 (0.60)^{cde}	28.70 (32.35)^{e}	53.04	5.30	3,000.00	65,525.00	1,48,521.33	82,996.33	2.27
4	Chlorantraniliprole 18.5 SC	180	0.32 (0.57)^{cd}	25.00 (29.94)^{de}	58.40	5.84	2,348.00	66,493.00	1,63,510.67	97,017.67	2.46
5	Azadirachtin 10,000 ppm	1200	0.50 (0.70)^{e}	40.74 (39.65)^{g}	41.11	4.11	895.00	59,850.00	1,15,098.67	55,248.67	1.92
6	Profenophos 50 EC	900	0.13 (0.36)^{a}	9.72 (18.00)^{a}	71.38	7.14	580.00	68,625.00	1,99,864.00	1,31,239.00	2.91
7	Novaluron 10 EC	300	0.19 (0.44)^{ab}	13.43 (21.31)^{b}	73.70	7.37	1,000.00	69,735.00	2,06,360.00	1,36,625.00	2.96
8	Indoxacarb 14.5 SC	240	0.25 (0.50)^{bc}	19.44 (26.13)^{c}	65.45	6.54	720.00	66,965.00	1,83,250.67	1,16,285.70	2.74
9	Thiodicarb 75 WP	600	0.29 (0.53)^{bc}	19.44 (26.03)^{c}	61.69	6.17	1,960.00	67,095.00	1,72,741.33	1,05,646.30	2.57
10	Control	-	1.18 (1.08)^{f}	63.89 (53.14)^{h}	37.51	3.75	0.00	69,125.00	1,05,028.00	35,903.00	1.52
$SE_m \pm$			0.03	1.03	3.70	0.37					
CD at 5%			0.10	3.07	10.99	1.10					
CV%			9.41	5.78	11.16	11.16					

Values in parentheses angular transformed; Mean values followed by the same letter within a column are not significantly different ($p \leq 0.05$); Standard check: Deltamethrin 2.8EC;Gross returns (Rs. /ha) = Fruit yield (t/ha) x Market price; Net returns (Rs. /ha) = Gross returns (Rs. /ha) – Total cost of production (Rs. /ha); Market price = Rs. 28.00

AUTHOR CONTRIBUTION STATEMENT

SKMH conceived and designed research. BJP conducted the experiments. SKMH contributed resources to carry out the research. BJP analyzed data and wrote the manuscript. SKMH corrected the manuscript.

CONFLICT OF INTEREST

The authors have no conflict of interest.

REFERENCES

Anonymous. 2020a. Package of practices of horticulture crops. Available from: https://e-krishiuasb.karnataka.gov.in/ (1st November, 2020).

Anonymous. 2020b. Rimon special features. https://www.indofil agro. com. Accessed 14th November, 2020.

Bisane K D, Dhane A S, Singh S, Irulandi S, Patil P. 2018. Insect pests of sapota in India - Monograph. ICAR-IIHR, Bengaluru. pp. 14-16.

Bisane K D, Naik B M, Modi P K, Patel A P. 2022. Evaluation of insecticide schedules against seed borer *Trymalitis margarias* Meyrick in sapota. Pesticide Research Journal 34(2): 209-214.

Bisane K D, Naik B M. 2016. Varietal performance of sapota against bud and seed boring insect pests under South Guajrat condition. International Journal of Tropical Agriculture 34(5): 1207-1210.

Bisane K D, Naik B M. 2021a. Impact and reliability of weather factors on occurrence of sapota seed borer *Trymalitis margarias* Meyrick. International Journal of Tropical Insect Science 41: 1729-1737.

Bisane K D, Naik B M. 2021b. Evaluation of sapota varieties against seed borer *Trymalitis Margarias* Meyrick. Indian Journal of Entomology 83(4): 606-609.

Bisane K D, Saxena S P, Naik B M. 2017. Bio-efficacy of newer insecticides against sapota seed borer *Trymalitis margarias* Meyrick. Journal of Entomology and Zoology Studies 5(3): 1853-1856.

Bisane K D, Shinde B D, Saxena S P, Patil P. 2019. Management of sapota seed borer *Trymalitis margarias* Meyrick with some newer pesticides. Pesticide Research Journal 31(1): 48-53.

Bisane K D. 2016. Seasonal cyclicity and behaviour of sapota seed borer *Trymalitis margarias* Meyrick. Pest Management in a Horticultural Ecosystem 22(2): 129-133.

Cutler G C, Scott-dupree C D. 2007. Novaluron: prospects and limitations in insect pest management. Pest Technology 1: 38-46.

Das G. 1986. Study of the feeder root system of some important varieties of sapota. M Sc Thesis, Odisha University of Agriculture and Technology.

Henderson C F, Tilton E W. 1955. Tests with acaricides against the brown wheat mite. Journal of Economic Entomology 48(2): 157-161.

Kanade B B. 2005. Comparative biology of seed borer *Trymailitys margarias* Meyrick (Totricidae: Lepidoptera), varietal screening of sapota and evaluation of insecticides for its management. Ph D thesis, Navasari Agricultural University Navasari.

Karthik R S. 2019. Investigations on biodiversity of borer complex and natural enemies on sapota (*Manilkara achras*) in Andhra Pradesh. Ph D thesis, YSR Horticultural University, West Godavari (Dist.).

Khambhu C V, Bisane K D. 2015. Population dynamics and management of sapota seed borer, *Trymalitis margarias* (Meyrick). Pest Management in Horticultural Ecosystem 21(2): 125-130.

Makwana D M. 2002. Biology of sapota seed borer *Trymalitis Margarias* Meyrick (Tortricidae: Lepidoptera) and evaluation of some insecticides for its management. PhD thesis, Navasari Agricultural University Navasari.

Patel P K, Bisane K D, Naik B M. 2020. Estimation of fruit damage deviation due to seed borer *Trymalitis margarias* Meyrick under different varieties and spacing in sapota. Journal of Entomological Research 44(4): 505-510.

Patel P K, Bisane K D. 2020. Assessment of avoidable losses due to seed borer *Trymalitis margarias* Meyrick in different varieties of sapota under high density plantation. Pest Management in Horticultural Ecosystems 26(1): 29-34.

Patel Z P. 2002. Insect pests of sapota and their management. Management of Insect pests, diseases and physiological disorders of fruit crops. pp.110-113.

Patil B J, Suchithra Kumari M H, Revannavar R, Shivaprasad M, Kumar Y S H, Hanumantharaya L. 2020. Seasonal incidence of sapota seed borer, *Trymalitis margarias* Meyrick (Lepidoptera: Tortricidae) in Mudigere. Journal of Entomology and Zoology Studies 8(6): 1267-1274.

Preetha G, Manoharan T, Kuttalam S, Stanley J. 2007. Ovicidal action of insecticides against the noctuid pests of cotton. Journal of Plant Protection and Environment 4(2): 55-59.

Shilpa S, Nadaf A M, Renuka B H, Kantharaju V, Sabarad A I, Naika M B. 2023. Evaluation of different insecticides against sapota seed borer *Trymalitis margarias* Meyrick. Journal of Experimental Zoology India 26(2): 1695-1703.

Shinde B D, Sanap P B, Narangalkar A L, Dahiphale A V, Dalvi N V. 2014. Bioefficacy of insecticides against sapota seed borer *Trymalitis margarias* Meyrick. Journal of Plant Protection and Environment 11(2): 36-38.

Suchithrakumari M H, Yalleshkumar H S, Hanumantharaya L, Sachin U S, Srinivas M P. 2018. Evaluation of insecticides against sapota midrib folder *Banisia myrsusalis elearalis* Walker in the hill zone of Karnataka. Journal of Entomology and Zoology Studies 6(5): 217-222.

Vijayaraghavendra R, Basavanagoud K. 2017. Evaluation of insecticides against sapota fruit borer *Phycita erythrolophia* Hampson. Journal of Entomology and Zoology Studies 5(5): 1358-1361.

(Manuscript Received: April, 2023; Revised: September, 2023;
Accepted: September, 2023; Online Published: September, 2023)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e23247