Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(6): 1267-1274

Received: 16-09-2020
Accepted: 25-10-2020

Bharati Jambunatha Patil
Department of Entomology, College of Horticulture, Mudigere, Chikkamagaluru University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Suchithra Kumari MH
Department of Entomology, College of Horticulture, Mudigere, Chikkamagaluru University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Revanna Revannavar
Department of Entomology, College of Horticulture, Mudigere, Chikkamagaluru, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Shivaprasad M
Zonal Agricultural and Horticultural Research Station, Mudigere, Chikkamagaluru, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Yallesh Kumar HS
Department of Fruit Science, College of Horticulture, Mudigere, Chikkamagaluru, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

L Hanumantharaya
Professor and Head
Department of Entomology
College of Horticulture, Mudigere, Chikkamagaluru University of Agricultural and Horticultural sciences, Shivamogga, Karnataka, India

Corresponding Author:
Bharati Jambunatha Patil
Department of Entomology, College of Horticulture, Mudigere, Chikkamagaluru University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Seasonal incidence of sapota seed borer, *Trymalitis margarias* Meyrick (Lepidoptera: Tortricidae) in Mudigere

Bharati Jambunatha Patil, Suchithra Kumari MH, Revanna Revannavar, Shivaprasad M, Yallesh Kumar HS and L Hanumantharaya

DOI: https://doi.org/10.22271/j.ento.2020.v8.i6q.8008

Abstract
An investigation on seasonal incidence of sapota seed borer, *Trymalitis margarias* Meyrick was carried out during 2019-2020. The seed borer infestation was observed throughout the study period but the intensity varied in Kalipatti and Cricket Ball cultivars, where the maximum infestation was documented in *cv.* Kalipatti than in Cricket Ball. The minimum seed borer infestation was noticed during September 2019 (5.13 and 2.56% fruit damage) while the maximum was in March 2020 (51.92 and 30.13% fruit damage) in Kalipatti and Cricket Ball cultivars, respectively. Rainfall had a significant negative correlation with seed borer infestation (r= -0.757 and -0.765, respectively) while significant positive influence was observed in case of maximum temperature (r= 0.788 and 0.713, respectively), maximum relative humidity (r= 0.661 and 0.676, respectively) and bright sunshine hours (r= 0.866 and 0.708, respectively) in both the cultivars.

Keywords: Correlation, Cricket Ball, Fruit Damage, Kalipatti, Sapota Seed Borer, Seed Damage

1. Introduction
Sapota is a hardy crop and farmers are unable to estimate the yield loss caused by the insect pests because of its continuous flowering and fruiting habit. The pest problem in sapota is aggravated with extensive cultivation of *cv.* Kalipatti because of its excellent quality and introduction of new insect pests. Sapota Seed Borer (SSB), *Trymalitis margarias* is a monophagous microlepidopteran pest belonging to the family Tortricidae attacking immature fruits of sapota. It is non-native to India and it was suspected that *T. margarias* might have been accidentally introduced in India from Sri Lanka through cargo *via* sea route and established over a while [6]. This pest was first reported from the Dahanu areas of Maharashtra (Patel, 2001) [12]. In India, sapota is produced in an area of 89,000 ha with a production of about 10,59,000 MT during 2018-19. The second advance estimate for 2019-20 indicated that the sapota area and production might be reduced to 83,000 ha and 10,03,000 MT, respectively [17]. Nearly 1,133.77 MT of sapota with a value of 721.22 lakhs got exported to various countries during 2019-20 [18]. Karnataka is the second-largest producer of sapota followed by Gujarat (29,550 ha area and 3,26,360 MT production) with an area of 25,310 ha and production of about 3,15,380 MT [2].

Trymalitis margarias is an internal feeder that feeds exclusively on the endosperm of the seed and hence, is named sapota seed borer. After completing its larval period, SSB comes out for pupation by tunneling through the pulp through 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 (Plate 1). The loss due to fruit damage by SSB was estimated to the tune of 40 to 90 per cent in Maharashtra [13], 54 per cent in Gujarat [10] and 14.73 per cent in Bengaluru [1]. There was a huge loss in sapota yield in this area as well due to the seed borer incidence. Therefore, the necessity to document the seasonality of seed borer on sapota and the influence of different weather parameters on its activity was felt and hence, the study was taken up.

2. Materials and methods
The experiment on seasonal incidence of seed borer was carried out from September 2019 to June 2020 on Kalipatti cultivar in the sapota blocks maintained at Krishi Vigyan Kendra,

Mudigere while, on *cv*. Cricket Ball, was carried out in College of Horticulture, Mudigere, Chikkamagaluru district, Karnataka. Mudigere is located in the Agro-climatic region VI, Zone 9 (Hill zone) of Karnataka and the region is characterized by a massive rainfall area along the Western Ghats in South India.

Randomized Complete Block Design (RCBD) with two treatment (cultivars Kalipatti and Cricket Ball) and 13 replications was adopted in the experiment. The trees of each cultivar (Kalipatti and Cricket Ball) were marked for recording observations. The observations were recorded by destructive sampling at monthly intervals. In each variety and replication, medium-sized immature fruits were randomly harvested from all four directions equally either manually or by using venture fruit plucker wherever it was not reachable.

The sampled fruits were observed for the presence and absence of any exit holes externally and their number and size by measuring with the help of a graduated scale to ascertain the damage by seed borer and fruit borer. Irrespective of exit holes, all fruit samples were cut open and observed for the presence of larva, tunneling damage in the fruit pulp. The fruits were also observed for tunneling damage in the seeds and symptoms like exit holes, galleries and endosperm damage in the sapota seeds as well as the presence of the larvae and its developmental stage were observed and noted. The per cent fruit damage and seed damage was worked out with the help of the following formula.

$$\text{Per cent fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Number of sampled fruits}} \text{ x } 100$$

$$\text{Per cent seed damage} = \frac{\text{Number of damaged seeds per fruit}}{\text{Total number of seeds per fruit}} \text{ x } 100$$

The daily weather data (rainfall, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and bright sunshine hours) was collected from Zonal Agricultural Horticultural Research Station (ZAHRS), Mudigere. Karl Pearson's correlation coefficients were worked out using SPSS (Statistical Product and Service Solutions) software while linear regression analysis was done using Microsoft excel.

3. Results and discussion

3.1 Seed borer infestation on sapota

The seed borer infestation on sapota fruits was noticed throughout the study period with varying levels of infestation in Kalipatti and Cricket Ball cultivars (Figure 1 and Table1). Earlier studies also on the seasonal incidence of sapota seed borer reported the fluctuation in seed borer larval population throughout the investigation period [4, 6, 3, 16].

Kalipatti recorded significantly highest mean seed and fruit damage (27.05 and 29.61%, respectively) because of the highest mean larval population (0.20 No. /fruit) than *cv.* Cricket Ball (14.88 and 14.82%, 0.13 No. /fruit, respectively) indicating its more preference towards *cv.* Kalipatti than Cricket Ball. Seed borer infestation commenced from September 2019 with the minimum fruit damage (5.13 and 2.56% in Kalipatti and Cricket Ball, respectively) and seed damage (7.60 and 1.90% in Kalipatti (lower) and Cricket Ball (lowest), respectively). This was because of the least larval load (0.04 and 0.02 No. /fruit in Kalipatti and Cricket Ball, respectively) which coincided with the highest rainfall, lowest maximum temperature and bright sunshine hours during the study period (Figure 1 and Table 1).

The infestation then increased in Kalipatti and Cricket Ball cultivars from October 2019 to March 2020 with the peak fruit damage in March 2020 (51.92 and 30.13%, respectively) and seed damage in February to March (39.13 (higher) and 30.48% (highest), respectively). This was due to increasing larval activity (0.37 and 0.19 No. /fruit, respectively) that coincided with decreasing rainfall (December 2019, February and March 2020 were the drier months), rising maximum temperature and bright sunshine hours. After that, the infestation subsided from April to June 2020 on seeds (32.90 - 4.42% in Kalipatti (lowest) and 20.29 - 4.07% in Cricket Ball) and fruit (30.77 - 9.62% in Kalipatti and 17.95 - 7.14% in Cricket Ball) again because of the lower larval population corresponding to the increasing rainfall, decreasing maximum temperature and bright sunshine hours (Figure 1 and Table 1).

The present findings are in line with the lowest seed borer infestation during the first fortnight of September 2014 (0.33% fruit damage) and the highest during the first fortnight of December 2014 (13.70% fruit damage) in *cv.* Kalipatti but in Cricket Ball, the lowest fruit damage was recorded during the second fortnight of September (0.22%) while the highest during the first fortnight of December (10.52%). Zero fruit infestation was documented during June, July and August 2014 in both the sapota cultivars [10]. Similarly, the earlier studies reported the highest seed borer activity during December (16.00% fruit damage) [11], May (22.76% infestation) [4] and in October (10.50% fruit damage) coinciding with the fruit harvesting period [16] while the lowest incidence was observed during July (2% infestation) [4], which are in partial agreement with the present investigation.

Further, the present findings can also be supported partially by the earlier findings where the lowest fruit damage was recorded during the second fortnight of July (0.33%) and the highest fruit damage was observed in the first fortnight of December (12.33%) [3]. However, sapota seed borer had two peak periods of activity during January and November with 12.21 per cent and 14.72 per cent fruit damage, respectively [6]. Similarly, the highest fruit damage by sapota seed borer was found during 41st Standard Meteorological Week (SMW) (08 - 14 October) *i.e.*, 8.39 per cent fruit damage followed by 7.93 per cent during 40th SMW (01 - 07 October) considering the pooled data (2014 - 2016). The lowest fruit damage was noticed during 24th SMW (11 - 17 June) (0.20% fruit damage). However, the Zero incidence of *T. margarias* was recorded during 10 to 16th SMW, 25 to 31st SMW and 01 to 09th SMW [15]. Further, the peak infestation was noticed during November to January (7.65 - 11.02% fruit damage) and minimum fruit damage was noticed during July and August (0.46 - 2.93% fruit damage) [16].

Thus, from the present study on seasonal incidence of sapota seed borer, it can be concluded that the infestation was found throughout the year on both the cultivars of sapota with varying levels of infestation (peak during March and lesser during September) and that *cv*. Kalipatti was more preferred over *cv*. Cricket Ball.

3.1.1 Influence of weather parameters on the seasonal incidence of sapota seed borer

3.1.1.1 Influence on seed borer infestation

Correlation and regression studies between sapota seed borer infestation and weather variables indicated that rainfall had a significant negative correlation with the larval population in *cv*. Kalipatti and Cricket Ball (r= -0.757 and -0.765, respectively) and so the fruit (r= -0.863 and r= -0.850, respectively) and seed damage (r= -0.850 and -0.797, respectively) were also negatively influenced by rainfall in a significant way (Table 2). Earlier studies also revealed the significant negative influence of rainfall (r= -0.145, -0.425, -0.481 and -0.410, respectively) on fruit damage due to seed borer [8, 10, 3, 16]. Further, the variance or coefficient of determination in the linear regression model for the number of larvae, fruit damage and seed damage concerning rainfall were 0.573 and 0.590, 0.745 and 0.727, 0.723 and 0.635 in Kalipatti and Cricket Ball cultivars, respectively. The goodness of fit was high for fruit damage in both the cultivars and for seed damage in *cv*. Kalipatti. The goodness of fit was relatively high for the number of larvae in both the cultivars and seed damage in *cv*. Cricket Ball (Figure 2-4).

The maximum temperature had a significant positive correlation with the larval population in Kalipatti and Cricket Ball cultivars (r= 0.788 and 0.713, respectively). It hence influenced the fruit (r= 0.810 and 0.814, respectively) and seed damage (r= 0.757 and 0.811, respectively) in the same manner (Table 2). Parallel findings were observed in the earlier studies where the maximum temperature had a significant positive correlation with seed borer damage ((r= 0.427 and 0.443, respectively) in *cv*. Kalipatti [15, 9]. However, there was a non-significant negative correlation between maximum temperature and seed borer damage in Kalipatti and Cricket Ball cultivars (r= -0.106 and -0.210, respectively) which is in contrast with the present findings [10]. Further, regression equations regarding the relationship between maximum temperature and seed borer infestation supported the present findings with the variance values of 0.623 and 0.504, 0.657 and 0.662, 0.573 and 0.658 for the number of larvae, fruit damage and seed damage in Kalipatti and Cricket Ball sapota cultivars, respectively. The goodness of fit was relatively high for seed borer infestation concerning maximum temperature in Kalipatti and Cricket Ball cultivars of sapota (Figure 2-4).

Regarding bright sunshine hours, a significant positive relationship was observed with the seed borer infestation on Kalipatti and Cricket Ball cultivars *i.e*., number of larvae (r= 0.866 and 0.708, respectively) and in turn influenced the damage on fruits (r= 0.916 and 0.851, respectively) and seeds (r= 0.902 and 0.822, respectively) (Table 2). Similar studies also revealed that bright sunshine hours exhibited a significant positive correlation with seed borer damage (r= 0.427 and 0.402 in Kalipatti and Cricket Ball, respectively) [10, 3]. The variance or coefficients of determination in the linear regression model for the number of larvae, fruit damage and seed damage pertaining to bright sunshine hours were 0.750 and 0.502, 0.840 and 0.723, 0.814 and 0.677 in Kalipatti and Cricket Ball sapota cultivars, respectively. The goodness of fit was high with respect to the number of larvae and seed damage in *cv*. Kalipatti and fruit damage in both the cultivars but it was relatively high for the number of larvae and seed damage in *cv*. Cricket Ball (Figure 2-4).

Minimum temperature (r= -0.159 and -0.019, respectively) and minimum relative humidity (r= 0.381 and 0.519, respectively) exhibited non-significant negative correlation with seed borer larval activity on Kalipatti and Cricket Ball cultivars and hence influenced its damage on fruit (r= -0.273 and -0.226, respectively for minimum temperature; r= 0.461 and 0.501, respectively for minimum relative humidity) and seed (r= -0.338 and -0.265, respectively for minimum temperature; r= 0.395 and 0.489, respectively for minimum relative humidity) in the present study (Table 2). However, the present findings were in disparity with the earlier studies wherein the minimum temperature and relative humidity (r= -0.39 and -0.52, respectively) had a significant negative influence on seed borer damage [16]. The variance or coefficients of determination for the number of larvae, fruit damage and seed damage with regard to minimum temperature were 0.026 and 0.001, 0.075 and 0.052, 0.115 and 0.071 in Kalipatti and Cricket Ball cultivars of sapota, respectively. The goodness of fit was relatively low for sapota seed borer infestation in both the cultivars. The variances for seed borer infestation concerning minimum relative humidity were 0.145 and 0.268, 0.212 and 0.250, 0.155 and 0.239 for the number of larvae, fruit damage and seed damage in Kalipatti and Cricket Ball cultivars, respectively. The goodness of fit was low for seed borer infestation in both the cultivars (Figure 2-4).

Whereas, maximum relative humidity influenced seed borer larvae positively in a significant manner in Cricket Ball (r= 0.765) but not in Kalipatti (r= 0.581) and hence it influenced its damage on fruits (r= 0.661 and 0.676, respectively) and seeds (r= 0.675 and 0.746, respectively) in the present study (Table 2). The current findings were equal to observations made by earlier researchers, who found a significant positive correlation between relative humidity and seed borer damage [8]. However, there was a significant negative relationship with evening relative humidity with r= -0.793 and -0.735 in Kalipatti and Cricket Ball cultivars, respectively [10] and r= -0.666 in *cv*. Kalipatti [3]. The variance or coefficients of determination for the number of larvae, fruit damage and seed damage with respect to maximum relative humidity were 0.338 and 0.586, 0.436 and 0.457, 0.455 and 0.557 in Kalipatti and Cricket Ball cultivars, respectively. The goodness of fit was relatively high for the number of larvae and seed damage in *cv*. Cricket Ball while low goodness of fit was seen for the number of larvae and seed damage in *cv*. Kalipatti and fruit damage in both the cultivars of sapota for maximum relative humidity (Figure 2-4).

Thus from the present study, it can be concluded that the weather parameters certainly influenced the seed borer activity to a greater extent. In a broader sense, the seed borer infestation increased with decreasing rainfall, increasing maximum temperature, increasing maximum relative humidity and bright sunshine hours and vice versa in both the cultivars.

Table 1: Seasonal incidence of sapota seed borer, *T. margarias* on Kalipatti and Cricket Ball cultivars during 2019-20

Sl. No.	Month	Per cent damage			
		Fruit damage		Seed damage	
		Kalipatti	Cricket Ball	Kalipatti	Cricket Ball
1.	September 2019	5.13 (13.09)^{b}	2.56 (9.21)^{a}	7.60 (16.00)^{de}	1.90 (7.92)^{b}
2.	October 2019	10.26 (18.68)^{de}	8.33 (16.78)^{cd}	13.84 (21.84)^{fg}	10.63 (19.03)^{ef}
3.	November 2019	19.23 (26.01)^{fg}	10.26 (18.68)^{de}	20.02 (26.58)^{h}	17.02 (24.37)^{gh}
4.	December 2019	35.26 (36.43)^{jk}	18.59 (25.54)^{f}	40.40 (39.47)^{j}	19.14 (25.94)^{h}
5.	January 2020	39.10 (38.71)^{kl}	23.08 (28.71)^{gh}	41.92 (40.35)^{j}	19.26 (26.03)^{h}
6.	February 2020	44.23 (41.69)^{l}	19.23 (26.01)^{fg}	43.37 (41.19)^{j}	18.41 (25.41)^{h}
7.	March 2020	51.92 (46.10)^{m}	30.13 (33.29)^{i}	39.13 (38.72)^{j}	30.48 (33.51)^{i}
8.	April 2020	30.77 (33.69)^{ij}	17.95 (25.07)^{f}	32.90 (35.00)^{i}	20.29 (26.77)^{h}
9.	May 2020	25.00 (30.00)^{h}	11.54 (19.86)^{e}	19.23 (26.01)^{h}	7.02 (15.36)^{cd}
10.	June 2020	9.62 (18.64)^{de}	7.14 (15.50)^{bc}	4.42 (12.14)^{c}	4.07 (2.02)^{a}
Mean		27.05	14.88	29.61	14.82
SEm±		0.99		1.12	
CD @ 5%		3.05		3.46	
CV %		13.24		15.04	

Figures in the parentheses are angular transformed
Mean values followed by the same letter within and between the columns are not significantly different ($P \leq 0.05$).

Table 2: Influence of weather parameters on the seasonality of sapota seed borer, *T. margarias* on Kalipatti and Cricket Ball cultivars during 2019-20

Weather parameter		Correlation coefficient					
		Number of larva per fruit		Per cent damage			
				Fruit damage		Seed damage	
		Kalipatti	Cricket Ball	Kalipatti	Cricket Ball	Kalipatti	Cricket Ball
Rainfall (mm)		-0.757*	-0.765*	-0.863**	-0.853**	-0.850**	-0.797**
Temperature (°C)	Max.	0.788**	0.713*	0.810**	0.814**	0.757*	0.811**
	Min.	-0.159	-0.019	-0.273	-0.226	-0.338	-0.265
Relative humidity (%)	Max.	0.581	0.765**	0.661*	0.676*	0.675*	0.746*
	Min.	0.381	0.519	0.461	0.501	0.395	0.489
Bright sunshine hours (Hours/day)		0.866**	0.708*	0.916**	0.851**	0.902**	0.822**

**Correlation is significant at the $P \leq 0.01$ level (2- tailed)
* Correlation is significant at the $P \leq 0.05$ level (2- tailed).

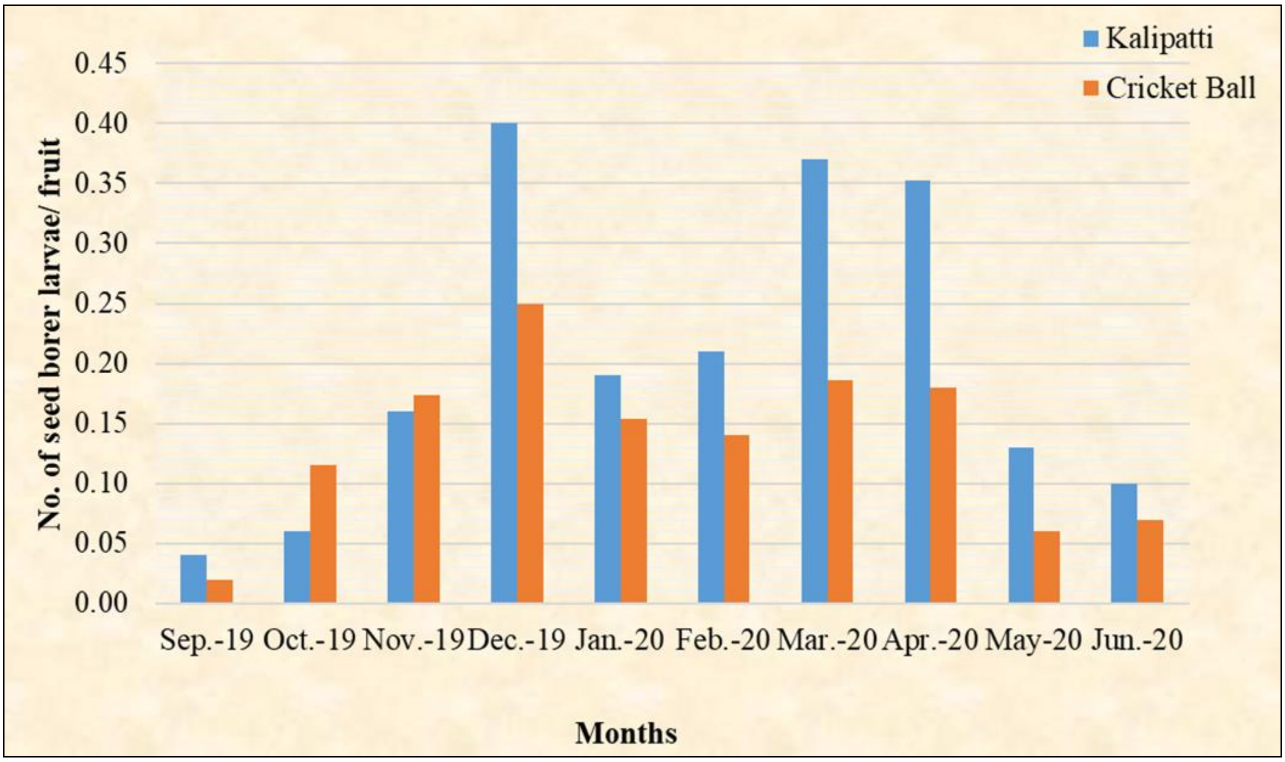

Fig 1: Seasonal incidence of sapota seed borer, *T. margarias* larvae on Kalipatti and Cricket Ball cultivars during 2019-20

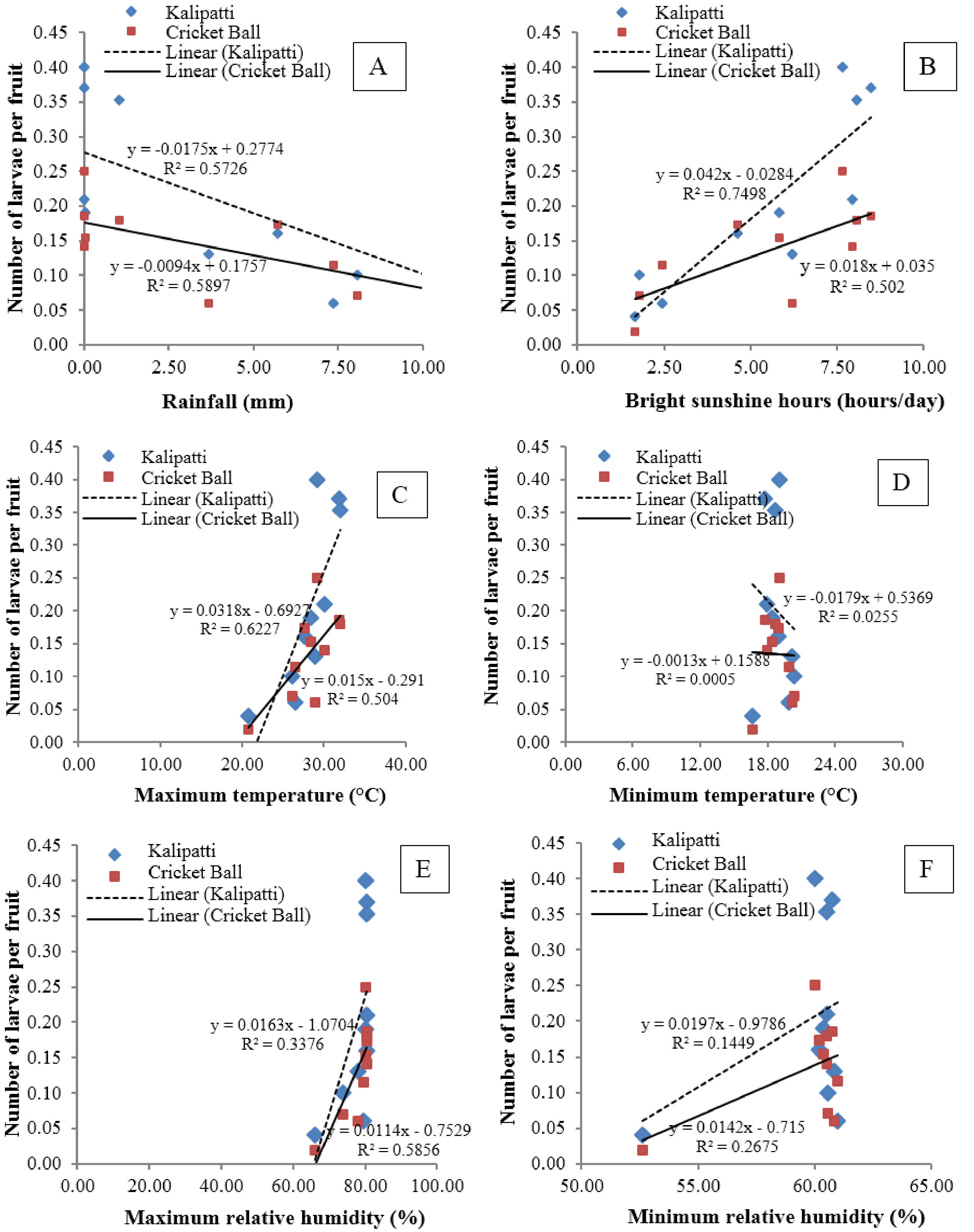

Fig 2: Influence of weather parameters on sapota seed borer, *T. margarias* larvae in Kalipatti and Cricket Ball sapota cultivars during 2019-20 (A–F)

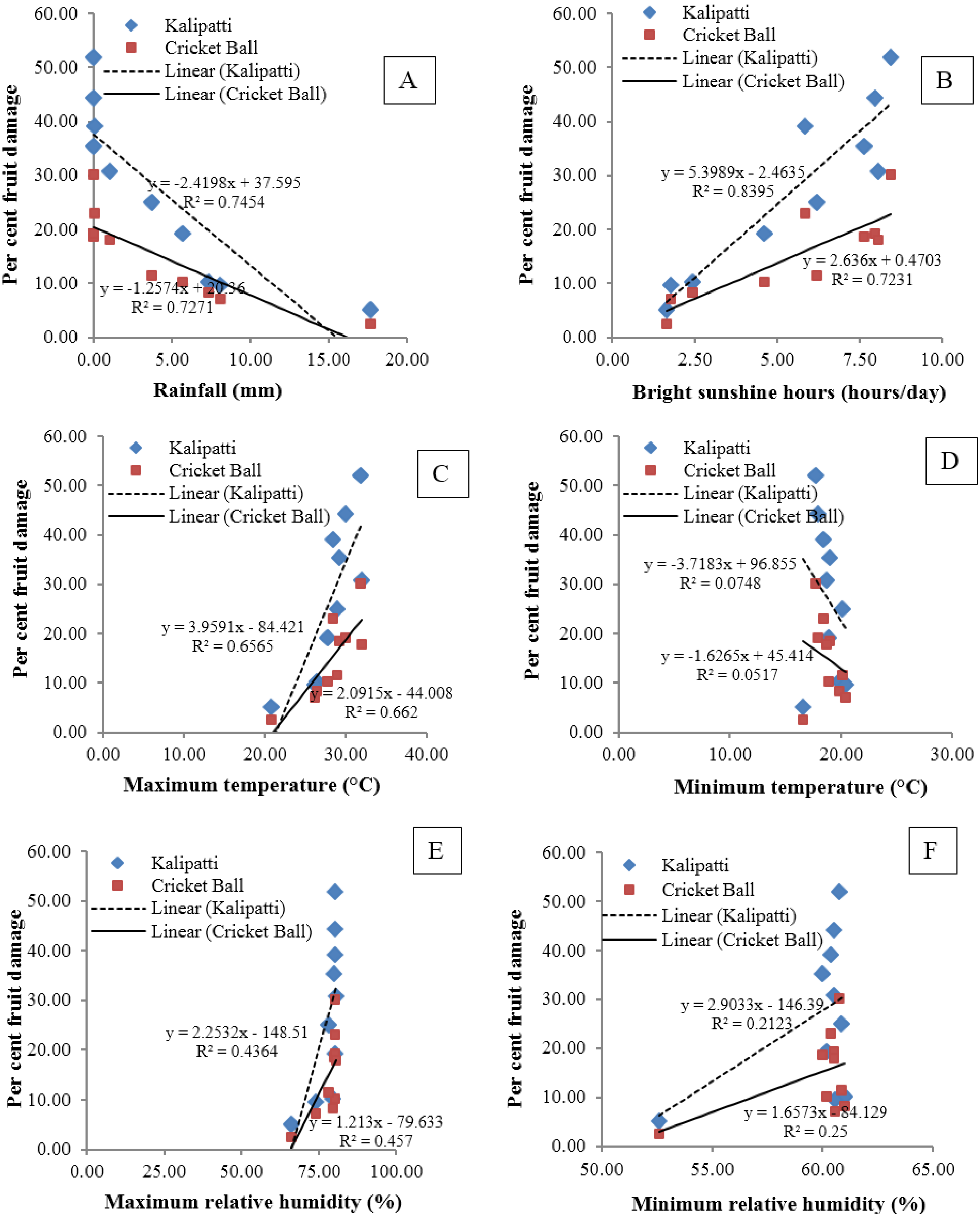

Fig 3: Influence of weather parameters on per cent fruit damage due to sapota seed borer, *T. margarias* in Kalipatti and Cricket Ball sapota cultivars during 2019-20 (A-F)

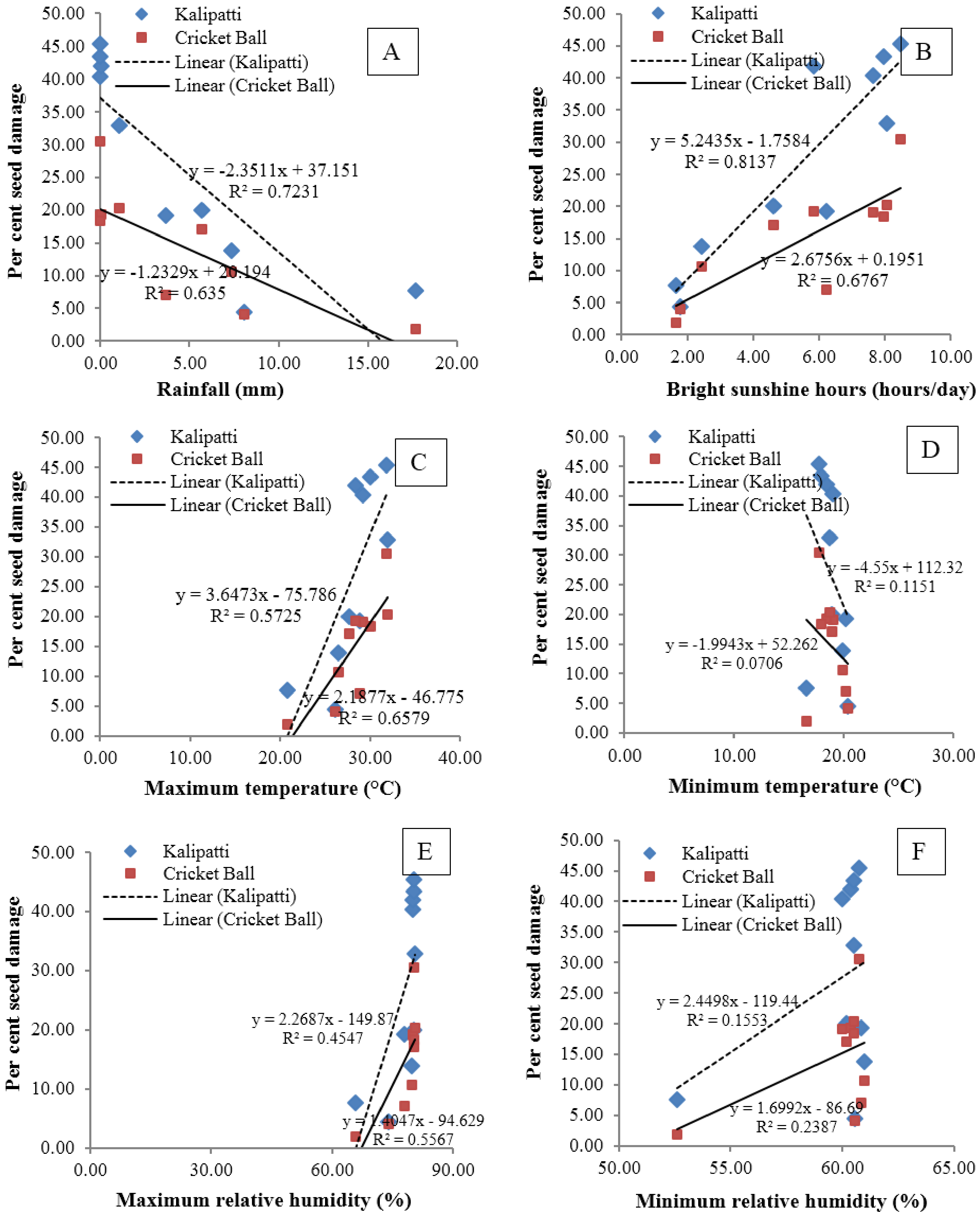

Fig 4: Influence of weather parameters on per cent seed damage due to sapota seed borer, *T. margarias* in Kalipatti and Cricket Ball cultivars during 2019-20 (A–F)

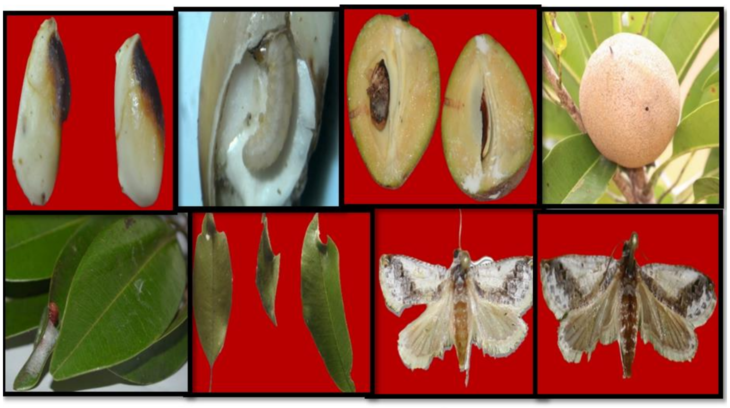

Plate 1: Nature of damage of sapota seed borer, *T. margarias*

4. Conclusion
From the present study, it could be concluded that the seed borer infestation was noticed throughout the year on Kalipatti and Cricket Ball cultivars of sapota with varying levels of infestation. The peak infestation was noticed during March and lesser during September and *cv*. Kalipatti was more preferred over *cv*. Cricket Ball by sapota seed borer. Further, during the study period, the influence of weather parameters on seed borer infestation was more pronounced. In a broader sense, the seed borer infestation increased with decreasing rainfall, increasing maximum temperature, increasing maximum relative humidity and bright sunshine hours and vice versa in both the cultivars.

5. Acknowledgement
We would like to extend our sincere thanks to Dean (Hort.), College of Horticulture, Mudigere, Sr. Scientist and Head, KVK, Mudigere and Sr. Farm Superintendent, Zonal Agricultural and Horticultural Research Station (ZAHRS) and department of fruit science, College of Horticulture, Mudigere for extending the facilities of the experimental site to conduct this research and the Directorate of Research, University of Agricultural and Horticultural Sciences, Shivamogga for providing financial assistance to conduct the investigation.

6. References
1. Annual report. Indian Institute of Horticulture Research, Bangalore 2008, 37p.
2. Anonymous. Horticulture statistics at a glance. Department of Agriculture, cooperation and farmers welfare, Ministry of Agriculture and Farmers Welfare Government of India 2018, 490p.
3. Bisane KD. Seasonal cyclicity and behavior of sapota seed borer, *Trymalitis margarias* Meyrick. Pest Management in Horticultural Ecosystems 2016;22(2):129-133.
4. Dumbre MR, Desai BD, Mule RS, Mehendele SK, Jalgaonkar, VN. Studies on seasonal incidence and biology of sapota seed borer, *Trymalitis margarias* Meyrick in Thane district. Pestology 2004;28(6):50-3.
5. Garad GM. Studies on integrated management of sapota seed borer and bud borer. M.Sc. Thesis, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli 2004.
6. Godase VN. Bioecology and management of sapota seed borer, *Trymalitis margarias* Meyrick (Tortricidae: Lepidoptera). M.Sc. Thesis, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli 2006.
7. Jayanthi PK, Verghese A. Sapodilla seed borer, *Trymalitis margarias* Meyrick: An invasive or indigenous species?. Pest Management in Horticultural Ecosystems 2010;16(2):141-147.
8. Kalpana B. Bioecology and management of sapota seed borer, *Trymalitis margarias* Meyrick (Tortricidae: Lepidoptera). Ph.D. thesis, University of Agricultural Sciences, Bengaluru 2003.
9. Kanade BB. Comparative biology of seed borer, *Trymalitis margarias* Meyrick (Tortricidae: Lepidoptera) varietal screening of sapota and evaluation of insecticides for its management. Ph.D. Thesis, Gujarat Agriculture University, Anand 2005.
10. Khambhu CV. Seasonal abundance of important pest of sapota and evaluation of insecticides against seed borer. M.Sc. Thesis, Navasari Agricultural University, Navasari 2015.
11. Makwana DM. Biology of sapota seed borer, *Trymalitis Margarias* Meyrick (Tortricidae: Lepidoptera) and evaluation of some insecticides for its management. M.Sc. Thesis, Navasari Agricultural University, Navasari 2002.
12. Munj YA, Mule SR, Narangalkar LA. Integrated management of sapota seed borer, *Trymalitis margarias* Meyrick. Pestology 2014;38(8):36-39.
13. Patel ZP. Record of seed borer in sapota (*Manilkara achras* (Mill) Forseberg). Insect Environment 2001;6(4):149p.
14. Patel ZP. Insect pests of sapota and their management. Management of Insect pests, diseases and physiological disorders of fruit crops 2002, 110-113.
15. Patel SD. Study on pest succession, varietal screening against important insect-pests and management of bud boring insects of sapota. Ph.D. Thesis, Navsari Agricultural University, Navsari 2016.
16. Shinde BD, Narangalakar AL, Shinde YA, Sanap PB, Bhagat SB, Dalvi NV, *et al*. Effect of weather parameters on the activity of sapota seed borer, *Trymalitis margarias* Meyrick under Konkan conditions of Maharashtra. Ecology, Environment and Conservation 2016;22:267-268.
17. Shukla. Seasonal incidence and biology of Sapota seed borer, *Trymalitis margarias* Meyrick. Pakistan Entomologist 2009;31(2):107-110.
18. Department of Agriculture, cooperation and farmers welfare. http://agricoop.nic.in/statistics/horticulture.f
19. Food Products Export Development Authority, Govt. of India. http://agriexchange.apeda.gov.in.