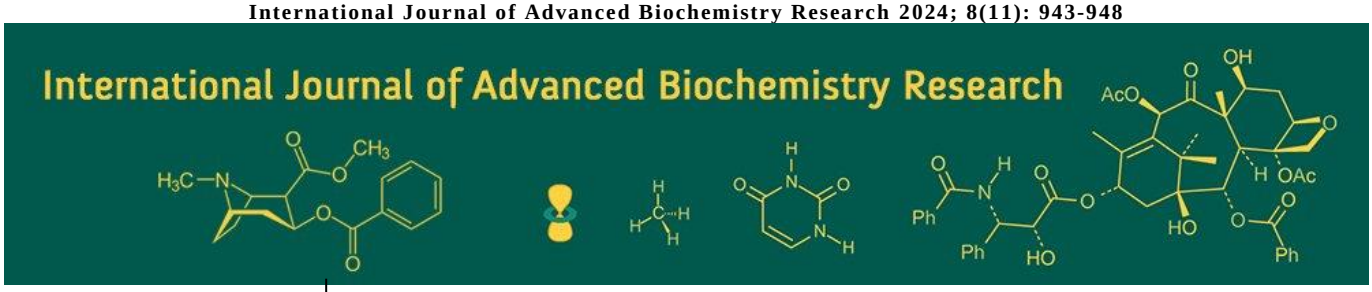

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Damage potential of sapota seed borer, *Trymalitis margarias* and impact of physico-chemical parameters under West Godavari district

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Abstract
The studies on seasonal incidence of sapota seed borer, *Trymalitis margarias* on var. Kalipatti and influence of morphological and biochemical parameters against seed borer on thirteen varieties of sapota during 2023-24 at Dr.YSRHU, HRS, Venkataramannagudem. Per cent fruit damage was maximum (11.00%) during first fortnight of November and minimum (1.00%) in second fortnight of February. Correlation studies revealed that per cent fruit damage had a significant positive effect with maximum relative humidity (0.73**). However, among morphological parameters number of seeds (-0.41^{NS}) showed significant and negative correlation with the per cent leaf damage while, biochemical studies revealed that Total Soluble Solids (0.62*) and reducing sugars (0.70**) exhibited significant positive correlation with per cent fruit damage.

Keywords: Seed borer, correlation, TSS, reducing sugars, total sugars

Introduction
Sapota, also known as sapodilla (*Manilkara achras*), native to Mexico which is a significant tropical fruit belongs to Sapotaceae family. Formerly, sapota cultivation began in Maharashtra in 1898. India is the world's largest producer of sapota with an area of 78.60 thousand hectares and production of 822 thousand MT (Horticultural Statistics at Glance, 2020-21). Major growing states of sapota are Gujarat, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, Haryana, Punjab, and West Bengal (Vijayaraghavendra and Basavanagoud, 2017) [20]. In Andhra Pradesh sapota crop is being cultivated in 12.88 thousand hectares with the production of 193.20 thousand tonnes (Horticultural Statistics at Glance, 2020-21).

Sapota seed borer, *Trymalitis margarias* is a monophagous, micro-lepidopteran pest belongs to the family Tortricidae which targets immature fruits of sapota. It is an exotic pets and accidentally introduced from Sri Lanka through sea route and established over a while in India. It was first reported from Dahanu of Maharashtra in 2000, later spread to neighbouring sapota growing belts of Valsad and Navsari of Gujarat (Patel, 2001). Since its introduction, now this pest has been established in major sapota growing states of Gujarat, Maharashtra, Tamil Nadu and Karnataka (Jayanthi and Verghese, 2010) [7] and recently in Andhra Pradesh (Sunitha *et al*.,2020) [19].

Sapota is a hardy crop and farmers are unable to assess yield loss caused by insect pests due to its continuous flowering and fruiting habit. The pest problem in sapota is provoked with extensive cultivation of var. Kalipatti because of its excellent quality and introduction of new insect pests. Under monoculture of kalipatti, seed borer become emerging insect pest for sapota causing very serious damage at peak fruiting stage, which deteriorates the quality of fruit and posing threat to export as it directly affects the seed. With magnitude of seed borer damage intensity, succession of pest was investigated to ensure the present status of seed borer seasonal cyclicity, behaviour and influence of physico-chemical properties against seed borer in the field under West Godavari district.

Materials and Methods

The investigation on seasonal incidence of sapota seed borer, morphological and biochemical parameters in relation to seed borer infestation were carried out at Horticultural Research Station, Dr. Y.S.R. Horticultural University, Venkataramannagudem (16.83°N latitude and 81.5°E longitude) during 2023-24. The experiment was laid out in Randomized Block Design (RBD) with three replications. No insecticidal spray was done on the trees during the investigation.

The observations on seasonal incidence of seed borer and its correlation with weather factors on kalipatti variety (> 25 years old) were selected for the trail. Ten fruits per tree were selected from each replication and observations were recorded at fortnight intervals. Per cent fruit infestation due to seed borer was calculated by using the formula given by Makwana (2002)

$$\text{Per cent bud damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

The impact of morphological and biochemical parameters against sapota seed borer was investigated on thirteen varieties *viz*., Pala, Kirthibarthi, Virudhnagar, DHS-1, DHS-2, Kalipatti, Pakala, Cricket Ball, Gavarayya, Dwarapudi, Guthi, CO-3 and PKM-4. Morphological parameters such as number of seeds, fruit shape, fruit surface texture and pulp texture while, biochemical traits such as total soluble solids (TSS), reducing sugars, non- reducing sugars and total sugars were recorded on ten matured fruits from each variety. Digital refractometer was used to determine the TSS. Standard techniques were used to determine reducing sugars, non-reducing sugars and total sugars. The data were statistically analysed.

Results and Discussion

Seasonal incidence of sapota seed borer (*T. margarias*)

Per cent fruit damage due to seed borer varied from 1.00% to 11.00% during August 2023 to June 2024 (Table 1). The per cent fruit infestation was initiated with 2.00% during first fortnight of September and it was at the peak (11.00%) during first fortnight of November and thereafter it declined progressively from second fortnight of November (10.00%) to second fortnight of February (1.00%) least fruit damage was observed. It was evident that seed borer activity was influenced by availability of fruits. The present results are in line with the findings of Makwana (2002) [10] who stated that peak activity of seed borer was observed during September to December. However, Shukla (2009) [18] recorded that per cent fruit damage due to sapota seed borer was maximum during October and November. As well as Khambhu and Bisane (2015) [9] and Bisane and Naik (2022) [2] identified the highest fruit damage in December. Bisane (2016) [3] reported that peak activity of seed borer was recorded during November. In contrast, Patil *et al*. (2020) [13] noticed maximum infestation due to seed borer in the month of March.

The correlation studies (Table 2 and Fig. 1) indicated that the per cent fruit damage due to seed borer showed positive significant correlation with maximum relative humidity (0.73**) whereas, remaining weather factors maximum temperature (-0.62^{NS}), minimum temperature (-0.44^{NS}), minimum relative humidity (0.09^{NS}) and rainfall (-0.25^{NS}) couldn't show significant influence on per cent fruit damage. Kalpana (2003) documented that relative humidity showed significant and positive effect with the per cent fruit damage whereas, Khambhu and Bisane (2015) [9], Bisane (2016) [3] and Shinde *et al*. (2016) [17] reported that the per cent fruit damage due to seed borer is negatively correlated with minimum temperature, relative humidity and rainfall. However, Patil *et al*. (2020) [13] revealed that the per cent fruit damage was positively correlated with maximum temperature and maximum relative humidity with significance while, there was a significant and negative correlation between per cent fruit damage and rainfall.

Table 1: Seasonal occurrence of sapota seed borer, *T. margarias* on sapota var. Kalipatti in relation to abiotic factors during 2023 - 24.

Year	Month	Fortnight	Maximum temperature (°C)	Minimum temperature (°C)	Maximum relative humidity (%)	Minimum relative humidity (%)	Rainfall (mm)	Percent fruit damage
2023	August	I	35.76	24.74	70.85	26.27	40.40	0.00
		II	35.88	25.10	71.30	25.00	28.60	0.00
	September	I	33.64	23.79	72.67	26.73	0.39	2.00
		II	32.78	23.89	79.86	30.93	1.13	4.22
	October	I	35.30	22.14	80.13	27.47	0.29	7.00
		II	34.52	22.18	82.34	37.41	0.06	8.00
	November	I	32.80	22.38	83.83	34.93	0.40	11.00
		II	32.51	22.21	83.45	35.53	0.17	10.00
	December	I	29.00	20.02	84.00	34.93	0.08	7.67
		II	29.17	17.82	84.00	34.00	0.00	5.00
2024	January	I	30.07	18.32	83.50	40.07	0.00	4.33
		II	32.84	18.26	83.67	31.09	0.00	2.00
	February	I	35.44	19.27	82.78	41.27	0.00	1.11
		II	37.22	20.36	72.93	35.07	0.00	1.00
	March	I	39.96	22.91	76.47	35.20	0.00	0.00
		II	40.72	23.27	79.38	27.44	0.00	0.00
	April	I	42.59	24.58	74.67	27.13	0.00	0.00
		II	44.27	26.55	75.00	26.27	0.00	0.00
	May	I	43.18	29.47	74.60	32.33	0.30	0.00
		II	40.04	27.86	75.60	46.31	1.30	0.00
	June	I	34.20	25.47	71.34	43.42	0.05	0.00
		II	34.54	24.18	70.17	39.47	0.02	0.00

Table 2: Correlation analysis between seed borer, *T. margarias* and weather parameters on Kalipatti variety of sapota during 2023 - 24.

Variety	Maximum temperature (ºC)	Minimum temperature (ºC)	Maximum relative humidity (%)	Minimum relative humidity (%)	Rainfall (mm)
Kalipatti	-0.62^{NS}	-0.44^{NS}	0.73**	0.09^{NS}	-0.25^{NS}

**Correlation co-efficient at 1% level of significance
*Correlation co-efficient at 5% level of significance
NS – Non-Significant

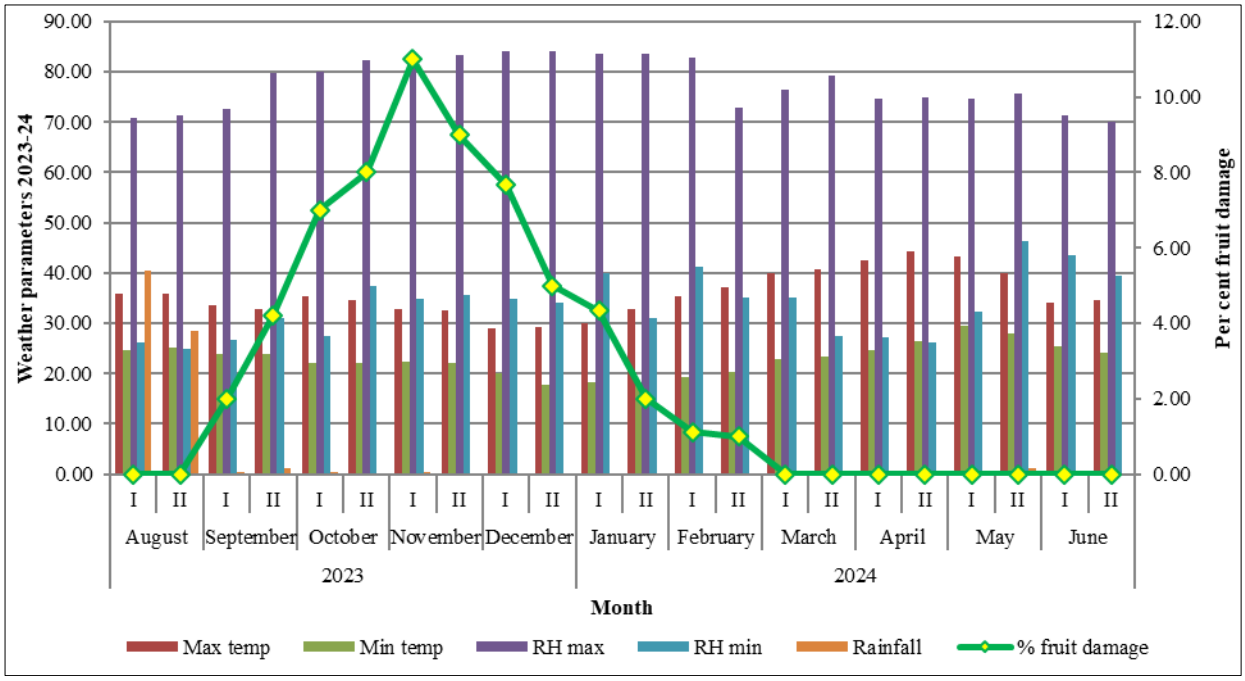

Fig 1: Seasonal occurrence of sapota seed borer (*T. margarias*) relation to abiotic factors var. Kalipatti during 2023 – 24

Morphological parameters

a. Shape of the fruit

Fruit shape of sapota varieties exhibited three distinct shapes *i.e*., round, flat round and oval (Table 3). Oval shaped fruits such as Pala, Kirthibarthi, Virudhnagar, Kalipatti, Gavarayya and PKM-4 while, DHS-1, Pakala, Cricket Ball, Dwarapudi, Guthi and CO-3 have round shaped fruits. Moreover, the DHS-2 was flat round. RS K (2018) [14] documented no correlation between fruit shape and per cent fruit damage due to seed borer. Gaur and Yadav (2023) reported that guava varieties with oblong fruit shape (Banarasi Surkha and 1-49) had higher fruit fly infestation while, Desi with sub-globose fruits had lower incidence.

b. Surface texture of fruit

Data among thirteen varieties of sapota revealed that fruit skin was classified into smooth and rough (Table 3). The varieties with smooth surfaces found in Pala, Virudhnagar, DHS-1, DHS-2, Kalipatti, Pakala, Cricket Ball, Gavarayya, Dwarapudi, Guthi, CO-3 and PKM-4 while, rough texture was noticed in Kirthibarthi. No correlation was found between surface texture of fruit and per cent fruit damage. RS K (2018) [14] revealed that no correlation was observed in between surface texture of fruit and per cent fruit infestation due to seed borer.

c. Pulp texture

Based on data with respect to pulp texture, thirteen varieties of sapota were classified as smooth or granular (Table 3). Smooth texture was observed in Pala, Pakala, Gavarayya, Guthi, and CO-3 while, Kirthibarthi, Virudhnagar, DHS-1, DHS-2, Kalipatti, Cricket Ball, Dwarapudi and PKM-4 showed granular pulp. The per cent fruit damage due to seed borer showed no correlation with pulp texture. Similar to our results, Sharma *et al*. (2008) [16] identified no correlation between castor capsule borer incidence and fruit characteristics such as fruit length, fruit breadth and percentage of fruit pulp in guava while, RS K (2018) [14] also reported no correlation between pulp texture and fruit damage by seed borer in sapota.

d. Number of seeds

The mean number of seeds per fruit among thirteen sapota varieties exhibited a range from 3.65 to 6.41 seeds (Table 3). The highest seed count per fruit was observed in the Gavarayya (6.41) variety followed by Cricket Ball (6.32) and lowest in DHS-2 (3.65). Correlation studies in the present investigation elucidated that the seed number/ fruit in thirteen sapota varieties exerted a negative influence (-0.41^{NS}) with mean per cent fruit damage by seed borer, *T. margarias* which was non-significant. Sharma *et al*. (2008) [16] evaluated morphological parameters of different guava cultivars against fruitfly and castor capsule borer incidence. It was evident that fruitfly, *Bactrocera dorsalis* damage was positively increased with diameter and maturity of the fruit increased. Coloured genotypes had the lowest castor capsule borer damage**.** However, the fruit damage by fruit fly and castor capsule borer did not show any correlation with fruit length and fruit breadth. Similar to our results earlier, Patel *et al*. (2020) [12] who presented that the morphological characteristics such as fruit weight, color, shape of fruit and seed along with number of seeds/fruits of different sapota varieties did not show association with the infestation level

of seed borer. Earlier, Choudhary *et al*. (2018) [4] tested morphological traits (Peel thickness, pulp content, fruit length and fruit diameter) of ten popular mango varieties against fruit fly and stated that the fruit length and fruit diameter had significant positive correlations whereas, peel thickness of fruits had significant negative correlation with mean percent fruit damage due to fruit fly.

Table 3: Influence of morphological parameters against sapota seed borer (*T. margarias*) during 2023 - 24.

Varieties	% Fruit damage	Number of seeds	Surface texture of fruit	Shape of the fruit	Pulp texture
Pala	5.12	4.00	Smooth	Oval	Smooth
Kirthibarthi	4.61	6.00	Rough	Oval	Granular
Virudhnagar	4.49	5.20	Smooth	Oval	Granular
DHS- 1	4.83	4.10	Smooth	Round	Granular
DHS-2	4.83	3.65	Smooth	Flat Round	Granular
Kalipatti	5.28	4.67	Smooth	Oval	Granular
Pakala	2.10	5.32	Smooth	Round	Smooth
Cricket Ball	1.61	6.32	Smooth	Round	Granular
Gavarayya	4.03	6.41	Smooth	Oval	Smooth
Dwarapudi	4.01	5.47	Smooth	Round	Granular
Guthi	3.60	4.32	Smooth	Round	Smooth
CO- 3	2.90	4.81	Smooth	Round	Smooth
PKM- 4	2.41	4.59	Smooth	Oval	Granular
Correlation co-efficient		-0.41^{NS}	-	-	-

**Correlation co-efficient at 1% level of significance
*Correlation co-efficient at 5% level of significance
NS – Non significant

Biochemical parameters

1. Total Soluble Sugars (TSS)

Data on the total soluble solids (TSS) in thirteen varieties of sapota fruits revealed that TSS was highest in Pala (23.81°B) variety followed by Kirthibarthi (22.62°B), DHS-2 (22.38°B), Kalipatti (22.24°B), Pakala (21.92°B), Virudhnagar (21.91°B), DHS-1 (21.74°B), Dwarapudi (21.45°B), CO-3 (21.36°B), PKM-4 (20.79°B), Guthi (20.73°B), Cricket Ball (20.59°B), and Gavarayya (20.33°B) (Table 4). In our present studies, TSS exhibited a significant positive correlation (0.62*) with the per cent fruit damage caused by seed borer. The current results are in accordance with the findings of Gaur and Yadav (2023) who reported that varieties of guava with the highest TSS showed a positive correlation with fruit damage caused by fruit flies. In contrast, Sharma *et al*. (2008) [16] documented that the extent of fruit damage caused by the castor capsule borer and fruit fly in guava did not exhibit any correlation with TSS levels. Choudhary *et al*., 2018 [4] and Ashoka and Patil (2020) observed that the damage inflicted by fruit flies on mango displayed a positive correlation with TSS levels.

2. Reducing Sugars (%)

The data on reducing sugars among thirteen varieties of sapota was observed to range from 6.89% to 9.64% (Table 4). The highest percentage of reducing sugars was identified in Pala (9.64%) variety followed by Dwarapudi (9.33%), Kalipatti (9.29%), Virudhnagar (9.07%), Kirthibarthi (9.03%), Guthi (8.81%), PKM-4 (8.57%), Gavarayya (8.53%), CO-3 (8.36%), DHS-2 (8.32%), DHS-1 (8.07%), Pakala (8.02%) and Cricket Ball (6.89%). During the present investigation, reducing sugars exhibited a significant positive correlation (0.70**) with seed borer infestation.

3. Non-reducing sugars (%)

The percentage of non-reducing sugars among thirteen varieties of sapota exhibited a range from 1.32% to 2.79% (Table 4). The maximum proportion of non-reducing sugars was documented in CO-3 (2.79%) variety succeeded by Cricket Ball (2.52%), Gavarayya (2.51%), PKM-4 (2.37%), DHS-2 (2.14%), DHS-1 (2.03%), Guthi (1.71%), Kalipatti (1.63%), Kirthibarthi (1.63%), Dwarapudi (1.58%), Pala (1.52%), Virudhnagar (1.38%) and Pakala (1.32%). Amount of per cent non-reducing sugars in the fruits of tested varieties of sapota exhibited a non-significant negative correlation (-0.40^{NS}) with the per cent fruit damage. The present results align with the findings of RS (2018) [14] who recorded that non-reducing sugars showed negative non-significant correlation with seed borer infestation.

4. Total sugars (%)

The per cent of total sugars in sapota varieties was evaluated and ranged from 9.34% to 11.16% (Table 4). Pala variety exhibited the highest sugar content with 11.16% followed by CO-3 (11.15%), Gavarayya (11.04%), PKM-4 (10.94%), Kalipatti (10.92%), Dwarapudi (10.91%), Kirthibarthi (10.66%), Guthi (10.52%), DHS-2 (10.46%), Virudhnagar (10.45%), DHS-1 (10.10%), Cricket Ball (9.41%) and Pakala (9.34%). The per cent fruit damage due to seed borer exhibited a non-significant positive correlation with the total sugar content (0.51^{NS}). The current results are in line with the findings of RS K (2018) [14] who indicated that total sugars of sapota cultivars exhibited the positive (non-significant) correlation with per cent fruit damage. In confirmation to our studies, Sharma and Singh (2010) documented that the total sugars contained in okra germplasm had shown positive influence on infestation of fruit borers.

Table 4. Influence of biochemical parameters against sapota seed borer (*T. margarias*) during 2023 - 24.

Varieties	% fruit damage	TSS (°B)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
Pala	5.12	23.81	9.64	1.52	11.16
Kirthibarthi	4.61	22.62	9.03	1.63	10.66
Virudhnagar	4.49	21.91	9.07	1.38	10.45
DHS- 1	4.83	21.74	8.07	2.03	10.10
DHS-2	4.83	22.38	8.32	2.14	10.46
Kalipatti	5.28	22.24	9.29	1.63	10.92
Pakala	2.10	21.92	8.02	1.32	9.34
Cricket Ball	1.61	20.59	6.89	2.52	9.41
Gavarayya	4.03	20.33	8.53	2.51	11.04
Dwarapudi	4.01	21.45	9.33	1.58	10.91
Guthi	3.60	20.73	8.81	1.71	10.52
CO- 3	2.90	21.36	8.36	2.79	11.15
PKM- 4	2.41	20.79	8.57	2.37	10.94
Correlation co-efficient		0.62*	0.70**	-0.40^{NS}	0.51^{NS}

**Correlation co-efficient at 1% level of significance
*Correlation co-efficient at 5% level of significance
NS – Non significant

Conclusion

The growth of sapota varieties through the introduction and selection is important. The study on morphological and biochemical parameters of sapota varieties showed different variations among the germplasm. This gives the prospect to select germplasm on the basis of desirable characters. The improved variety of sapota may be developed using the variability of collected genotypes.

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