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Assessment of avoidable losses due to seed borer, *Trymalitis margarias* Meyrick in different varieties of sapota under high density plantation

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ABSTRACT: Studies were conducted to assess avoidable losses due to seed borer, *Trymaliti margarias* Meyrick in eight varieties/hybrids of sapota under high density plantation (5 x5 m). The fruit infestation was found significantly maximum in Kalipatti (3.91%) and DHS 2 (3.13%) under protected condition in overall six fruit pickings. Whereas under unprotected plot, the significantly higher fruit damage of 7.81% was reported in Kalipatti, after that in DHS 2 (5.88%) and Cricket ball (5.00%). The maximum reduction of fruit damage was found in Kalipatti with 49.93%, after that in Cricket ball (48.00%) and DHS 2 (46.76%). However, the fruit damage reduction was less in PKM 4 (29.67) and PKM 3 (27.94%), which already had less fruit infestation under unprotected plot. In terms of avoidable losses on the basis of marketable fruits yield, the losses were anticipated more in Cricket ball (53.99%), Kalipatti (51.90%), DHS 2 (49.35%) and CO 3 (45.16%). However, the moderate to low avoidable losses were noted in DHS 1 (38.51%), PKM 3 (36.00%), PKM 1 (31.33%) and PKM 4 (28.70%).

Keywords: Avoidable losses, sapota, seed borer, *Trymalitis margarias,* high density plantation

INTRODUCTION

Sapota, *Manilkara achras* (Mill.) Fosberg, is an important tropiocal fruit crop of India In recent times, the concept of high density planting is gaining importance among sapota growers to enhance the productivity on small area after getting success in banana and mango in south Gujarat region. The number of insect and mite pests infesting sapota tree is 33 in India of which 23 are enlisted in Gujarat (Bisane *et al*., 2018). Under such circumstances, increasing pest interference on vegetative and reproductive parts has impact on the productivity of crop due to big span of 8-11 months between flowering to fruit maturity phase in sapota. Among them, seed borer, *Trymalitis margarias* Meyrick (Lepidoptera: Tortricidae) became an emerging insect pest causing very serious damage at peak fruiting stage, due to which the quality of fruit deteriorated and a foul smell released during storage and transport. Seed borer bores immature fruits of sapota and reaches to the seed by boring the seed coat and finally damages the kernel (cotyledon) of the fruit seed. The mature larvae emerge out of the infested fruit after completing feeding of cotyledon. A small exit hole is the only sign of pest damage. Later, ants make their entry into the bored fruits, leading to entry of microbial infection causing rotting of the infested fruit (Bisane, 2016).

Since its detection in 2000, about 21% incidence of seed borer was reported in Thane (Maharashtra) during 2001 (Dumbre *et al*., 2004 and Anonymous, 2001) as well as up to 40% during 2003–04 (Anonymous, 2004) and between 9.00 to 12.00% at core fruiting phase between 2013-15 at Gandevi (Gujarat) on Kalipatti (Bisane, 2016).

Now a days, growers expect harvesting more fruits per unit year with high density plantation at early fruiting stage to fetch higher market prices. Still there is no literature available on avoidable losses due to seed borer damage under high density plantation with major commercially cultivated varieties/hybrids. Therefore, a trial with an approach to know the extent of damage due to sapota seed borer was framed in protected and unprotected condition.

MATERIALS AND METHODS

The study on the fruit damage of sapota seed borer, *T. margarias* under protected condition with NAU plant protection schedule recommendation in comparison with unprotected condition was carried out at the farm of Fruit Research Station, Navsari Agricultural University, Gandevi, Gujarat (20.807545º N 73.022260º E) during 2018-19. The investigation was designed in Randomized Block Design (RBD) with three replications (one tree considered as one replication) on eight varieties/hybrids

Table 1. Fruit damage due to seed borer (*T. margarias*) and their reduction in different varieties of sapota during first and second picking

Variety	Fruit damage (%) * in 1st picking (Nov., 2018)		Reduction of fruit damage (%)	Fruit damage (%) * in 2nd picking (Dec., 2018) (%)		Reduction of fruit damage (%)
	Protected	Unprotected		Protected	Unprotected	
PKM 1	0.76 (4.09)	2.00 (7.95)	62.00	1.04 (5.84)	2.66 (7.67)	60.90
PKM 3	1.18 (6.22)	1.74 (7.48)	32.18	1.10 (6.01)	1.67 (7.33)	34.13
PKM 4	0.81 (4.22)	1.00 (4.62)	19.00	1.20 (6.28)	2.01 (8.03)	40.29
DHS 1	0.87 (4.36)	2.95 (9.83)	70.51	1.41 (6.68)	3.00 (9.88)	53.00
DHS 2	1.33 (6.54)	3.60 (10.86)	63.06	2.38 (8.66)	5.33 (13.16)	55.34
Kalipatti	2.11 (8.13)	6.00 (14.15)	64.83	3.00 (9.88)	11.67 (19.83)	74.29
Cricket ball	1.00 (4.62)	2.33 (8.47)	57.08	2.73 (9.26)	7.89 (16.25)	65.39
CO 3	0.48 (2.29)	0.56 (2.47)	14.29	0.85 (4.31)	1.43 (6.80)	40.55
CD at 5%	NS	4.61	--	NS	5.41	--
CV %	66.49	32.03	--	30.77	27.78	--

***** Figures in parentheses are arc sin transformed values.

Table 2. Fruit damage due to seed borer (*T. margarias*) and their reduction in different varieties of sapota during third and fourth picking

Variety	Fruit damage (%) * in 3rd picking (Jan., 2019)		Reduction of fruit damage(%)	Fruit damage (%) * in 4th picking (Feb., 2019)		Reduction of fruit damage (%)
	Protected	Unprotected		Protected	Unprotected	
PKM 1	1.26 (5.23)	2.53 (9.12)	50.19	1.75 (7.38)	3.07 (10.03)	42.99
PKM 3	1.35 (5.41)	2.00 (7.95)	32.50	1.29 (5.16)	2.41 (8.89)	46.47
PKM 4	1.74 (7.48)	2.33 (8.74)	25.32	1.62 (5.95)	2.67 (9.36)	39.32
DHS 1	1.58 (5.63)	2.67 (9.08)	40.82	2.70 (9.37)	3.72 (10.94)	27.41
DHS 2	2.11 (8.13)	5.37 (13.21)	60.70	3.12 (10.11)	6.39 (14.59)	51.17
Kalipatti	2.81 (9.56)	5.33 (13.34)	47.27	3.67 (10.96)	7.67 (16.07)	52.15
Cricket ball	2.56 (8.91)	5.00 (12.92)	48.80	2.64 (9.23)	4.67 (12.36)	43.46
CO 3	1.00 (4.62)	2.33 (8.47)	57.08	1.78 (7.62)	3.00 (9.88)	40.66
CD at 5%	NS	3.42	--	NS	2.45	--
CV %	49.20	18.84	--	31.47	12.15	--

* Figures in parentheses are arc sin transformed values.

viz., PKM 1, PKM 3, PKM 4, DHS 1, DHS 2, Kalipatti, Cricket ball and CO 3 under planting of high density at 5 x 5 m.

Under insecticide schedule of NAU recommendation, first spray of profenofos @ 1.5ml/l when fruits are at marble stage (October onwards) + after 15 days second spray of nuvaluron @ 0.5ml/l + after 15 days third spray of profenofos @ 1.5ml/l was applied. However, the fruit trees under unprotected (control) condition were kept free from insecticide spray during the investigation. For recording the infestation of seed borer, 100 matured fruits was examined for the presence of damage fruit at the time of fruit harvest and per cent incidence was worked out. The yield of healthy and damage fruits in each treatment were noted down to count the percentage of fruit losses due to seed borer and to calculate the avoidable loss in each variety. The total yield of marketable fruits was calculated after minimizing the damage fruit yield. The avoidable loss was calculated by following formula.

$$\text{Avoidable loss (\%)} = \frac{\text{Yield in treated tree} - \text{Yield in untreated tree}}{\text{Yield in treated tree}} \times 100$$

RESULTS AND DISCUSSION

First picking (November, 2018): The data presented in Table 1 indicated that all the eight varieties were found infested by seed borer under protected and unprotected plot during first picking (November, 2018). There were non-significant differences among varieties under protected condition and significant results noted in unprotected situation. Under protected condition, the fruit damage was observed less than 2% except Kalipatti in first picking. Whereas under unprotected plot, the maximum fruit damage of 6.00 and 3.60% was reported in Kalipatti and DHS 2. The low fruit infestation due to seed borer was recorded up to 1.00 and 0.56% in PKM 4 and CO 3, respectively.

In fruit damage difference under protected and unprotected, the higher reduction of fruit infestation was recorded in DHS 1 with up to 70.51%, afterward under Kalipatti (64.83%), DHS 2 (63.06%), PKM 1 (62.00%) and Cricket ball (57.08%). However, the fruit damage reduction was less in PKM 3 (32.18%), PKM 4 (19.00%) and CO 3 (14.29%), which already had less fruit infestation under unprotected plot.

Second picking (December, 2018): The observation on the fruit infestation due to seed borer under protected condition during second picking were non-significant among different varieties had less than 3% fruit damage (Table 1). There were statistically significant results noted in unprotected (control) situation and the higher fruit damage of 11.67 and 7.89% was reported in Kalipatti and Cricket ball, respectively. The low to moderate fruit infestation due to seed borer was recorded in PKM 3 (1.67%) and CO 3 (1.43%). The higher reduction of fruit damage was recorded in Kalipatti with 74.29% and afterward in Cricket ball (65.39%), PKM 1 (60.90%),

Table 3. Fruit damage percentage due to seed borer (*T. margarias*) and their reduction in different varieties of sapota during fifth and sixth picking

Variety	Fruit damage (%) * in 5th picking (March, 2019)		Reduction of fruit damage(%)	Fruit damage (%) * in 6th picking (April, 2019)		Reduction of fruit damage (%)
	Protected	Unprotected		Protected	Unprotected	
PKM 1	3.44 (10.68)	4.19 (11.71)	17.89	2.78 (9.54)	3.81 (11.07)	27.03
PKM 3	1.48 (6.93)	1.78 (7.56)	16.85	2.42 (8.83)	2.67 (9.36)	9.36
PKM 4	2.15 (8.28)	3.00 (9.73)	28.33	2.86 (9.49)	3.73 (11.10)	23.32
DHS 1	2.79 (9.60)	4.05 (11.56)	31.11	1.49 (6.87)	2.00 (7.95)	25.50
DHS 2	5.44 (13.29)	7.92 (16.28)	31.31	4.41 (11.84)	6.67 (14.90)	33.88
Kalipatti	6.22 (10.41)	8.67 (17.08)	28.25	5.67 (13.69)	7.50 (15.84)	24.41
Cricket ball	3.32 (10.41)	5.40 (13.26)	38.51	3.31 (10.46)	4.71 (12.18)	29.72
CO 3	2.35 (8.63)	3.67 (10.86)	35.96	1.74 (6.19)	2.00 (9.95)	13.00
CD at 5%	3.16	3.18	--	NS	3.58	--
CV %	17.56	14.83	--	27.02	18.12	--

* Figures in parentheses are arc sin transformed values.

Variety	Fruit damage (%) * - Average of 6 pickings		Reduction of fruit damage (%)
	Protected	Unprotected	
PKM 1	1.84 (7.13)	3.04 (5.59)	39.47
PKM 3	1.47 (6.42)	2.04 (8.10)	27.94
PKM 4	1.73 (6.95)	2.46 (8.60)	29.67
DHS 1	1.81 (7.09)	3.06 (9.87)	40.84
DHS 2	3.13 (9.76)	5.88 (13.83)	46.76
Kalipatti	3.91 (11.10)	7.81 (16.05)	49.93
Cricket ball	2.60 (8.81)	5.00 (2.57)	48.00
CO 3	1.37 (5.61)	2.16 (7.74)	36.57
CD at 5% (T)	1.83	1.45	--
CD at 5% (P)	1.59	1.26	--
CD at 5% (TxP)	4.49	3.56	--
CV %	35.22	20.35	--

***** Figures in parentheses are arc sin transformed values.
T= Treatment, P = Picking.

DHS 2 (55.34%) and DHS 1 (53.00%) in second picking. However, the fruit damage reduction was less in CO 3 (40.55%), PKM 4 (40.29%) and PKM 3 (34.13%).

Third picking (January, 2019): The data on fruit infestation under protected condition was found statistically similar among different varieties and noted less than 3% fruit damage (Table 2). Whereas under unprotected plot, the maximum fruit damage up to 5.37, 5.33 and 5.00% was reported in DHS 2, Kalipatti and Cricket ball, respectively. The low fruit infestation was recorded in CO 3, PKM 4 and PKM 3, which showed 2.33, 2.33 and 2.00% fruit damage, respectively. Among protected and unprotected damage differences, the higher reduction in fruit loss was noted in DHS 2 with 60.70%, after that in CO 3 (57.08%), PKM 1 (50.19%), Cricket ball (48.80%), Kalipatti (47.27%) and DHS 1 (40.82%). However, the fruit damage reduction was less in PKM 3 (32.50%) and PKM 4 (25.32%).

Fourth picking (February, 2019): Under protected condition, there were non-significant differences among varieties and had less than 4.00% fruit infestation during fourth picking (Table 2). Whereas under unprotected plot, the significantly maximum fruit damage up to 7.67 and 6.39% was reported in Kalipatti and DHS 2, respectively and subsequently in Cricket ball (4.67%). The low fruit infestation due to seed borer was recorded in PKM 4 (2.67%) and PKM 3 (2.41%). The higher reduction of fruit damage was recorded in Kalipatti with 52.15%, after that in DHS 2 (51.17%) and PKM 3 (46.47%) in fourth picking. However, the fruit damage reduction was comparatively less in Cricket ball (43.46%), PKM 1 (42.99%), CO 3 (40.66%), PKM 4 (39.32%) and DHS 1 (27.41%).

Fifth picking (March, 2019): During fifth picking, there were significant differences among varieties under protected and unprotected (control) situation (Table 3). The significantly higher fruit damage up to 6.22 and 5.44% was recorded in Kalipatti and DHS 2, respectively under protected plot. The low fruit infestation was reported in PKM 4 and PKM 3 with 2.15 and 1.48%, respectively. Whereas under unprotected plot, the maximum fruit damage up to 8.67, 7.92 and 5.40% was reported in Kalipatti, DHS 2 and Cricket ball, respectively. The low fruit infestation was found in PKM 4 (3.00%) and PKM 3 (1.78%).

In fruit loss differences under protected and unprotected plots, the higher reduction of fruit infestation was recorded in Cricket ball with 38.51%, followed by

Table 5. Fruit yield of sapota in different varieties of sapota under protected and unprotected plots

Variety	Yield of marketable fruits (kg/tree)		Yield of damaged fruits (kg/tree)		Avoidable loss (%)
	Protected	Unprotected	Protected	Unprotected	
PKM 1	54.97	51.00	1.03	1.50	31.33
PKM 3	43.19	48.50	0.64	1.00	36.00
PKM 4	46.68	46.02	0.82	1.15	28.70
DHS 1	58.43	54.83	1.07	1.74	38.51
DHS 2	48.78	49.44	1.55	3.06	49.35
Kalipatti	53.19	52.20	2.15	4.47	51.90
Cricket ball	27.75	30.37	0.75	1.63	53.99
CO 3	24.83	27.22	0.34	0.62	45.16
CD at 5%	9.75	17.01	0.31	0.82	--
CV(%)	12.45	21.61	16.86	24.58	--

CO 3 (35.96%), DHS 2 (31.31%), DHS 1 (31.11%), PKM 4 (28.33%) and Kalipatti (28.25%) in fifth picking. However, the fruit damage reduction was less in PKM 1 (17.89%) and PKM 3 (16.85%). The fruit damage variation in both protected and unprotected plot was lessening due to nearly fourth months of span passed out after spraying of insecticide schedule.

Sixth picking (April, 2019): The significantly maximum fruit damage up to 5.67 and 4.41% was reported in Kalipatti and DHS 2, respectively under protected condition (Table 3). The low fruit infestation was recorded in CO 3 and DHS 1 with 1.74 and 1.49%, respectively. Whereas under unprotected plot, the significantly higher fruit infestation up to 7.50 and 6.67% was reported in Kalipatti and DHS 2, respectively. The low fruit infestation of 2.00% was recorded in both DHS 1 and CO 3. The higher reduction of fruit infestation was noted in DHS 2 with 33.88%, after that in Cricket ball (29.72%), PKM 1 (27.03%), DHS 1 (25.50%), Kalipatti (24.41%) and PKM 4 (23.32%) in sixth picking. However, the fruit damage reduction was less in CO 3 (13.00%) and PKM 3 (9.36%).

Average per cent fruit damage and reduction:

The seed borer average fruit infestation status under protected and unprotected plot is presented in Table 4. There were significant differences among varieties under pooled results of both protected and unprotected (control) condition. Under protected condition, the significantly maximum average fruit damage of 3.91 and 3.13% was observed in Kalipatti and DHS 2, respectively. While, the low fruit infestation due to seed borer was recorded in Cricket ball, PKM 1, DHS 1, PKM 4, PKM 3 and CO 3, which showed 2.60, 1.84, 1.81, 1.73, 1.47 and 1.37 fruit damage, respectively. Whereas under unprotected plot, the significantly higher average fruit damage of 7.81% was reported in Kalipatti, after that in DHS 2 (5.88%) and Cricket ball (5.00%). The moderate fruit infestation due to seed borer was recorded in DHS 1 (3.06%) and PKM 1 (3.04%), while low damage was noted PKM 4, CO 3, and PKM 3 with 2.46, 2.16 and 2.04%, respectively.

In fruit damage differences under protected and unprotected, the higher reduction of fruit loss was recorded in Kalipatti with 49.93%, after that in Cricket ball (48.00%), DHS 2 (46.76%), DHS 1 (40.84%) and PKM 1 (39.47%). However, the fruit damage reduction was less in CO 3 (36.57%), PKM 4 (29.67) and PKM 3 (27.94%), which already had less fruit infestation under unprotected plot.

Previously, Khambhu and Bisane (2015) studied the seed borer damage status under high density plantation and found PKM 3, PKM 4 and CO 3 were less infested, while Kalipatti and Cricket ball recorded higher average fruit damage as well as PKM 1, DHS 1 and DHS 2 were moderately infested under unprotected condition.

Fruit yield (kg/tree) and avoidable losses

The data on marketable and damaged fruit yield of different varieties/hybrids is depicted in Table 5 along with per cent avoidable losses. There was no direct effect of seed borer on quantitative yield performance in different varieties and variation occurred only due to varietal differences, however the difference was observed

in damaged fruit yield. Seed borer affect the qualitative aspects of fruits and number of fruits reduced down due to its infestation. The results revealed that the higher marketable fruit yield under protected condition was noted in DHS 1 (58.43 kg/tree), PKM 1 (54.97 kg/tree) and Kalipatti (53.19 kg/tree). While, the higher marketable fruit yield under unprotected (Control) plot was recorded in DHS 1 (54.83 kg/tree), Kalipatti (52.20 kg/tree), PKM 1 (51.00 kg/tree) and DHS 2 (49.44 kg/tree). The yield of damaged fruits in protected and protected plot was found significantly different and the higher damaged fruits was noted in Kalipatti (2.15 kg/tree) and DHS 2 (1.55 kg/tree) under protected condition, while it was also more in Kalipatti (4.47 kg/tree) and DHS 2 (3.06 kg/tree) under unprotected plot.

In avoidable losses differences under protected and unprotected plot, the losses was more in Cricket ball (53.99%), Kalipatti (51.90%), DHS 2 (49.35%) and CO 3 (45.16%). However, the moderate to low avoidable losses were noted in DHS 1 (38.51%), PKM 3 (36.00%), PKM 1 (31.33%) and PKM 4 (28.70). There is no literature available on management of seed borer under high density plantation on different varieties of sapota, however there are few management trials conducted under normal plantation in various sapota growing regions on Kalipatti variety and are compared to seed borer fruit damage with present investigation. The better performance of profenophos 50 EC (0.075%) and novaluron 10EC (0.005%) was reported in the findings of Bisane *et al.* (2019). While in another study, ready-mix insecticide like deltamethrin 1 EC + triazophos 35 EC 0.036% and profenophos 40 EC + cypermethrin 5 EC 0.044% found better in findings of Khambhu and Bisane (2015).

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