Pest Management in Horticultural Ecosystems
Vol. 27, No.1 pp 4-10 (2021)

DOI Number: 10.5958/0974-4541.2021.00002.3

Sapota varietal performance under different spacing against bud borer, *Anarsia achrasella* Bradley and their management

K. R. SOLANKI[1] and K. D. BISANE[2*]

[1]Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari - 396 450, Gujarat, India

[2]ICAR-AICRP on Fruits, Fruit Research Station, Navsari Agricultural University, Gandevi - 396 360, Gujarat, India

[*]**E-mail:** kdbisane@yahoo.co.in

ABSTRACT: The varietal differences against bud borer, *Anarsia achrasella* Bradley under normal and high density plantations were studied during 2019-20 at Fruit Research Station, NAU, Gandevi, Gujarat, India. The average bud and flower damage due to bud borer in winter 2019-20 was maximum of 6.11, 5.90 and 5.80% in Kalipatti, DHS-1 and Cricket ball, respectively. However, the incidence of bud borer was comparatively less in PKM-1 (3.69%) and PKM-4 (4.22%). However during summer 2020, the highest infestation was reported in Kalipatti (13.34%), DHS-1 (9.40%) and PKM-4 (8.98%). While, the damage was less in PKM-1 (5.54%) and CO-3 (7.55%). The average infestation was found elevated in high density plantation (5.26 and 9.37%) than normal spacing (4.82 and 8.05%) during winter 2019-20 and summer 2020, respectively. Also, the incidence was noted higher in summer than winter among varieties. Under management trial, the average infestation after fourth spray revealed that Azadirachtin @ 2 ml/lit and Bt @ 2 g/lit were reported lower 5.95 and 6.94% damage, respectively after fourth spray along with 67.59 and 62.19% reduction over control. After that, *B. bassiana* @ 4 g/lit and Azadirachtin @ 1 ml/lit were recorded infestation up to 9.19 and 9.43%, respectively and showed reduction of 49.94 and 48.61% over control, respectively.

Keywords: Bud Borer, *Anarsia achrasella* sapota, varietal screening, spacing

INTRODUCTION

Sapota is a widely grown fruit under tropical conditions. Flowers can be seen almost throughout the year, thus fruit harvesting is achievable throughout the year particularly between October to June. In recent times, the concept of high density is becoming popular among growers to enhance the productivity in South Gujarat region. The number of insect and mite pests infesting sapota tree are 33 in India and 23 in Gujarat (Bisane *et al*., 2018). Under such circumstances, pest menace is one of the major hurdle in boosting the productivity of the crop due to big span of 10-11 months between flowering to fruit maturity phase in sapota. Among bud boring complex, bud borer (bud worm), *Anarsia achrasella* Bradley (Lepidoptera: Gelechiidae) is a major pest of sapota. A recent study revealed about 25-27% yield loss of sapota due to bud borer and chiku moth, *Nephopteryx eugraphella* (Ragonot) under South Gujarat condition (Bisane, 2018).

In Gujarat, Kalipatti is a commercial variety and has highest area under cultivation with a few some other varieties planted sporadically. Bisane and Naik (2019) revealed that bud borer causes damage round the year with the peak activity during April and June on cv. Kalipatti. As well, there are a few new varieties/hybrid released from southern part of India and tested for normal and high density planting in South Gujarat region to check suitability in the region. Still there is no literature accessible on comparable losses under different spacing plantations with new varieties/hybrids. In present era, there is enfold demand of safer and eco-friendly pesticides due to rising issues of chemical pesticide residue, food poisoning, effect on natural enemies, resurgence of pest, *etc*. Keeping these in view, research work was framed to assess the peak activity period of bud borer in different varieties of sapota under normal and high density plantation. Similarly, bio-efficacy of different bio-pesticides and botanicals were evaluated against bud borer in sapota.

MATERIALS AND METHODS

The study on the extent of fruit losses due to bud borer, *A. achrasella* under normal and high density plantations (HDP) was carried out at the farm of ICAR-AICRP (Fruits), Fruit Research Station, Navsari Agricultural University, Gandevi, Gujarat (20.807545º N 73.022260º E) during 2019-20. The investigation was designed and statistically analyzed in Factorial Randomized Block Design with three replications (one tree considered as one replication) on eight varieties/hybrids *viz.*, PKM-1, PKM-3, PKM-4, DHS-1, DHS-2,

Kalipatti (Local check), Cricket ball and CO-3 under two spacing plantation of 10 x 10 m (Normal spacing) and 5 x 5 m (HDP). However, the fruit trees were kept free from insecticide spray during the investigation.

For recording the infestation of bud borer, randomly selected 10 twigs per tree of each variety was observed around all sides of tree canopy at fortnightly interval. Total number of buds and flowers as well as damaged buds and flowers due to bud borer was counted on each twig and per cent bud and flower damage was calculated. The observations were recorded at fortnightly interval between October to January (Winter) and February to May (Summer) during 2019-20. The damage difference reaction of different varieties/hybrids over local check (Kalipatti) was calculated to check the susceptibility/ tolerance level.

In management trial, eight treatments *viz.*, Bt (*Bacillus thuringiensis* var. Kurstaki) 1 x 10^{11} CFU/g @ 2 g/l (T_1), *Beauveria bassiana* (1 × 10^8 CFU/g) @ 4 g/l (T_2), *Metarrhizium anisopliae* (1 × 10^8 CFU/g) @ 4 g/l (T_3), Azadirachtin (10000 ppm) @ 2 ml/l (T_4), Azadirachtin (10000 ppm) @ 1 ml/l (T_5), Karanj oil @ 1 ml/l (+ sticker) (T_6), profenophos 40% + cypermethrin 4% (Ready-mix) (Std. check) 44 EC 0.044% @ 1 ml/l (T_7) and control (T_8) were tested in randomized block design with 3 replication (2 trees/replication). The applications of treatments were done from first fortnight of March, 2019 at 15 days interval and total 4 sprays were given.

For recording the damage intensity of bud borer, randomly selected 10 twigs/tree of each treatment was observed around all sides of tree canopy at 1st, 3rd, 5th, 7th, 10th and 14th day after application. The similar methodology of screening was followed to record per cent bud and flower damage. The per cent damage reduction due to different treatments over control was calculated.

The fruit yield (kg/tree) was noted at each harvesting from October onwards and total yield calculated of each tree was calculated at end of season (April, 2020). The yield per tree was converted to ha basis for analysis. Also, incremental cost benefit ratio was calculated on ha basis. The incremental yield increase due to different treatments over control was calculated.

Table 1. Bud borer (*A. achrasella*) incidence in different varieties and spacing of sapota in winter, 2019-20

Variety	Bud and flower damage (%)* (Avg. of 8 fortnightly observations from October to January)			Variation over Kalipatti (%)
	S_1 (10 x 10m)	S_2 (5 x 5m)	Mean (V)	
PKM-1	3.13 (10.08)	4.25 (11.78)	3.69 (10.93)	-39.61
PKM-3	4.88 (12.64)	5.26 (13.11)	5.07 (12.87)	-17.02
PKM-4	4.05 (11.50)	4.39 (11.93)	4.22 (11.71)	-30.93
DHS-1	6.04 (14.13)	5.76 (13.63)	5.90 (13.88)	-3.44
DHS-2	4.38 (11.89)	5.03 (12.76)	4.70 (12.33)	-23.08
Kalipatti	5.93 (13.95)	6.28 (14.44)	6.11 (14.20)	--
Cricket ball	5.55 (13.49)	6.04 (14.07)	5.80 (13.78)	-5.07
CO-3	4.62 (12.24)	5.08 (12.84)	4.85 (12.54)	-20.62
Mean (S)	4.82 (12.53)	5.26 (13.10)	--	--
Variation over normal spacing (%)	--	9.12	--	--
	V	**S**	Interaction (V x S)	--
CD at 5%	0.87	0.43	NS	--
CV (%)	16.85			--

***** Figures in parentheses are arc sin transformed value. V= Variety, S= Spacing.

Table 2. Incidence of bud borer (A. achrasella) in different varieties and spacing of sapota in summer, 2020

Variety	Bud and flower damage (%)*(Avg. of fortnightly 8 observations from February to June)			Variation over Kalipatti (%)	Variation over winter (%)
	S_1 (10 x 10m)	S_2 (5 x 5m)	Mean (V)		
PKM-1	4.05 (11.31)	7.03 (15.17)	5.54 (13.24)	-58.47	50.14
PKM-3	7.35 (15.42)	9.03 (17.21)	8.19 (16.31)	-38.61	61.54
PKM-4	9.34 (17.64)	8.61 (16.77)	8.98 (17.21)	-32.68	112.80
DHS-1	8.41 (16.67)	10.40 (18.68)	9.40 (17.68)	-29.54	59.32
DHS-2	8.35 (16.62)	8.08 (16.33)	8.21 (16.47)	-38.46	74.68
Kalipatti	12.71 (20.75)	13.97 (21.76)	13.34 (21.25)	--	118.33
Cricket ball	7.00 (15.07)	9.92 (18.13)	8.46 (16.60)	-36.58	45.86
CO-3	7.16 (15.32)	7.95 (16.21)	7.55 (15.77)	-43.40	55.67
Mean (S)	8.05 (16.10)	9.37 (17.53)	--	--	--
% Variation over normal spacing	--	16.40	--	--	--
	V	**S**	Interaction (V x S)	--	--
CD at 5%	0.97	0.49	1.37	--	--
CV (%)		14.36		--	--

* Figures in parentheses are arc sin transformed value. V= Variety, S= Spacing.

RESULTS AND DISCUSSION

Varietal screening - Winter, 2019-20

Varieties: The average bud and flower damage due to bud borer showed the maximum infestation of 6.11 5.90, 5.80 and 5.07% in Kalipatti, DHS-1, Cricket ball and PKM-3, respectively (Table 1). However, the infestation was comparatively less in PKM-1 (3.69%), PKM-4 (4.22%), DHS-2 (4.70%), CO-3 (4.85%).

Spacing: The bud and flower damage was found higher in high density plantation (5.26%) as compare to normal density plantation (4.82%). Kalipatti was highly susceptible variety, while DHS-1, Cricket ball and PKM-3 had comparable less vulnerability reaction of 3.44, 5.07 and 17.02% with Kalipatti. Whereas, DHS-2 and CO-3 were showed less susceptibility of 23.08 and 20.62% than Kalipatti, respectively. In spacing, high density plantation had 9.12% more vulnerability than normal spacing.

Summer, 2020

Varieties: The significantly maximum mean bud and flower damage due to bud borer (13.34%) was estimated in local check, Kalipatti (Table 2). However, the mean infestation was also found higher of 9.40 and 8.98% DHS-1 and PKM-4, respectively. Other varieties *viz*., Cricket ball, DHS-2 and PKM-3 were showed 8.46, 8.21 and 8.19% damage. The damage was less in PKM-1 (5.54%) and CO-3 (7.55%).

Spacing: The bud and flower damage was estimated higher (9.37%) in high density plantation than normal spacing plantation (8.05%). There were significant interaction differences among varieties and spacing during summer, 2020. Here in normal and high density plantation, Kalipatti was found more susceptible with 12.71 and 13.97%, respectively and after that, DHS-1 (10.40%) and Cricket ball (9.92%) were found more susceptible under high density plantation. Whereas the variety PKM-1 was found tolerant in normal (4.05%) and high density plantation (7.03%).

The two varieties *viz.*, DHS-1 and PKM-4 had comparable susceptibility response with 29.54 and 32.68% less damage, respectively than Kalipatti. However, CO-3 and PKM-1 had less vulnerability reaction of 43.40 and 58.47%, respectively than Kalipatti. When per cent infestation disparity between winter and

summer estimated, the highest 118.33 and 112.80% increased damage was noted in summer than winter under Kalipatti and PKM-4, respectively. While, the increased damage between 59.32 to 74.68% was recorded in summer than winter under DHS-1, PKM-3 and DHS-2. In earlier findings, there was higher infestation of bud borer in Kalipatti, while damage was lower in PKM-1 under normal spacing (Anon., 2001). Also in recent past studies, Kalipatti, DHS-1 and Cricket ball were reported highly susceptible to bud borer as compare to tolerancy found in DHS-2 and PKM-1 under normal spacing during April and May (Anon., 2019a and 2020). In another study, Kalipatti, DHS-1 and PKM-5 showed higher susceptibility as compared to low damage in PKM-1 under normal spacing (Bisane and Naik, 2016 and Bisane, 2020). Under high density plantation, Khambhu and Bisane (2017) found lower average seasonal occurrence in CO-3, which was followed by Cricket ball and DHS-2, while higher mean infestation was noted in Kalipatti and PKM-3 The maximum infestation was observed during April and May. All these above findings reported from south agro-ecological circumstances of Gujarat and match more or less with present research results.

Table 3. Efficacy of different treatments on average bud and flower damage against bud borer (*A. achrasella*) in sapota

Tr. No.	I spray		II spray		III spray		IV spray	
	Avg. damage (%)*	% Reduction over control	Avg. damage (%)*	% Reduction over control	Avg. damage (%)*	% Reduction over control	Avg. damage (%)*	% Reduction over control
T_1	11.45 (19.7)	17.07	9.77 (18.04)	35.95	8.05 (16.33)	52.27	6.94 (15.11)	62.19
T_2	12.18 (20.36)	11.83	10.98 (19.22)	27.99	10.61 (18.86)	37.10	9.19 (17.46)	49.94
T_3	12.23 (20.26)	11.48	11.68 (19.74)	23.37	11.62 (19.72)	31.13	10.75 (19.03)	41.43
T_4	11.91 (19.91)	13.78	9.52 (17.83)	37.54	7.81 (16.05)	53.72	5.95 (13.97)	67.59
T_5	12.25 (20.34)	11.31	11.18 (19.39)	26.69	10.72 (18.93)	36.44	9.43 (17.79)	48.61
T_6	13.24 (21.21)	4.13	12.18 (20.25)	20.13	11.69 (19.87)	30.70	11.43 (19.65)	37.70
T_7	10.23 (18.53)	25.94	8.33 (16.57)	45.35	5.36 (13.28)	68.25	4.03 (11.50)	78.02
T_8	13.81 (21.72)	--	15.25 (22.87)	--	16.87 (24.20)	--	18.35 (25.33)	--
CD at 5% (T)	1.79	--	2.09	--	1.88	--	1.58	--
CD at 5% (D)	NS	--	NS	--	NS	--	NS	--
CD at 5% (TxD)	NS	--	NS	--	NS	--	NS	--
CV (%)	13.32	--	16.69	--	15.46	--	13.66	--

* Figures in parentheses are arc sin transformed value. DAT= Day after treatment, T= Treatment, S= Spray.

Table 4. Efficacy of different treatments on damage and yield against bud borer (*A. achrasella*) in sapota (Pooled of 4 sprays)

Tr. No.	Avg. bud and flower damage (%)* (Pooled of 4 sprays)							Reduction over control %	Fruit yield (t/ha)	ICBR
	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	14 DAT	Mean			
T_1	10.62 (18.81)	9.38 (17.64)	8.59 (16.80)	8.20 (16.42)	8.64 (16.93)	8.89 (17.16)	9.05 (17.29)	43.67	15.53	1.10
T_2	11.89 (20.06)	10.97 (19.12)	10.47 (18.64)	10.04 (18.36)	10.45 (18.79)	10.62 (18.86)	10.74 (18.98)	33.17	13.37	1.07
T_3	12.67 (20.62)	11.80 (19.86)	11.19 (19.32)	10.76 (19.02)	11.20 (19.46)	11.80 (19.85)	11.57 (19.69)	28.00	13.35	1.04
T_4	10.63 (18.75)	9.34 (17.46)	8.58 (16.85)	7.75 (15.86)	7.92 (16.04)	8.56 (16.7)	8.80 (16.94)	45.26	15.82	1.30
T_5	11.87 (20.02)	10.93 (19.07)	10.66 (18.93)	10.37 (18.54)	10.52 (18.84)	11.02 (19.28)	10.90 (19.11)	32.20	14.20	1.21
T_6	13.07 (20.97)	12.28 (20.43)	11.33 (19.59)	11.23 (19.36)	12.16 (20.33)	12.75 (20.8)	12.14 (20.25)	24.48	13.03	1.07
T_7	8.77 (16.79)	7.41 (15.57)	6.64 (14.67)	6.12 (13.95)	6.36 (14.26)	6.63 (14.58)	6.99 (14.97)	56.52	16.87	9.95
T_8	15.52 (23.11)	15.74 (23.31)	15.92 (23.42)	16.19 (23.61)	16.42 (23.83)	16.63 (23.91)	16.07 (23.53)	--	12.47	--
CD at 5% (T)	2.32	2.40	2.25	2.42	1.92	2.39	0.93	--	2.56	--
CD at 5% (S)	1.64	1.70	1.59	1.71	1.36	1.69	0.66	--	--	--
CD at 5% (TxS)	NS	NS	NS	NS	NS	NS	1.85	--	--	--
CV (%)	14.30	15.44	14.91	16.35	12.68	15.52	15.05	--	10.26	--

* Figures in parentheses are arc sin transformed value. DAT= Day after treatment, T= Treatment, S= Spray.

As well in other sapota growing regions, Vijayaraghavendra (2014) reported that the bud borer incidence was more in Cricket ball, followed by DHS-1, Kalipatti and less in DHS-2 as well as highest infestation level was noted from January to March under normal planting in Karnataka, while Vaja *et al.* (2018) reported that Cricket ball and Kalipatti were the most susceptible to bud borer damage and PKM-1 showed the least susceptibility under normal spacing in Western part of Gujarat.

Bio-efficacy of different biopesticides and botanicals

I spray: The minimum bud and flower damage of 10.23% due to bud borer was noted in profenophos 40% + cypermethrin 4% (T_7), which was also statistically similar to Bt (T_1), Azadirachtin (2 ml/l) (T_4), *M. anisopliae* (T_3), Azadirachtin (1 ml/l) (T_5) and *B. bassiana* (T_2) recorded 11.45, 11.91, 12.00, 12.23 and 12.18% damage, respectively. There was reduction of infestation up to 25.94% in profenophos 40% + cypermethrin 4% (T_7) over control (T_8) after first spray, while biopesticides and botanicals showed reduction between 4.13 to 17.07 % over control plot (T_8).

II spray: The minimum damage up to 8.33% due to bud borer was recorded in profenophos 40% + cypermethrin 4% (T_7), which was also comparable to Azadirachtin (2 ml/lit) (T_4) and Bt (T_1) with 9.52 and 9.77% damage, respectively. There was reduction of damage up to 45.35, 37.54 and 35.95% in profenophos 40% + cypermethrin 4% (T_7), Azadirachtin (2 ml/l) (T_4)

and Bt (T_1), respectively over control (T_8), while other biopesticides and botanicals showed per cent reduction between 20.13 to 27.99 over control (T_8).

III spray: The significantly lowest bud and flower damage of 5.36% due to bud borer was noted in profenophos 40% + cypermethrin 4% (T_7). However, among biopesticide and botanicals, Azadirachtin (2 ml/lit) (T_4) and Bt (T_1) were also reported lower infestation up to 7.81 and 8.05% after third spray. There was reduction of damage up to 68.25, 53.72 and 52.27% in profenophos 40% + cypermethrin 4% (T_7), Azadirachtin (2 ml/l) (T_4) and Bt (T_1), respectively over control (T_8).

IV spray: The significantly minimum bud and flower damage of 4.03% due to bud borer was recorded in profenophos 40% + cypermethrin 4% (T_7). Among biopesticide and botanicals treatments, Azadirachtin (2 ml/l) (T_4) and Bt (T_1) were also proved effective and reported lower 5.95 and 6.94% damage, respectively and found at par with each other after fourth spray. The other biopesticide and botanical *viz.*, *B. bassiana* (T_2) and Azadirachtin (1 ml/lit) (T_5) had moderate infestation up to 9.19 and 9.43%, respectively. After fourth spray, per cent reduction of bud and flower damage was 78.02, 67.59 and 62.19 in profenophos 40% + cypermethrin 4% (T_7), Azadirachtin (2 ml/l) (T_4) and Bt (T_1), respectively over control (T_8).

Average of four sprays (Pooled of 4 sprays): The significantly lowest bud and flower damage of 6.99% due to bud borer was noted in profenophos 40% + cypermethrin 4% (T_7) (Table 4). Among biopesticides and botanicals, Azadiractin (2 ml/lit) (T_4) and Bt (T_1) were also reported lower infestation up to 8.80 and 9.05 %. The highest damage of 16.07 % was observed in control plot (T_8) after four sprays. The difference between sprays revealed that the significant reduction trend in infestation due to effective treatments against bud borer was observed after second and third spray and found minimum after fourth spray. Likewise, there was significant reduction in infestation level at 5th and 7th day after treatments. There was reduction of damage up to 56.52, 45.26 and 43.67% in profenophos 40% + cypermethrin 4% (T_7), Azadiractin (2 ml/lit) (T_4) and Bt (T_1), respectively over control (T_8) after four sprays.

The better performance of profenophos 40% + cypermethrin 4% (Polytrin–C) and Bt was reported in study of Suryavanshi and Patel (2009). While, Shinde *et al.* (2010) compared different botanicals, biopesticides and newer insecticides and found Bt @ 1.5 g/lit and azadirachtin 1% @ 3 ml/l were effective after chemical insecticides over control. The module comprising profenophos 40% + cypermethrin 4% (Polytrin–C) was found superior for the management of sapota bud borer in the findings of Thumar *et al.* (2012). Ghirtlahre *et al.* (2015) showed that Spinosad 45 SC (0.0169 %), *B. thuringiensis* 5 WP (0.0075%) and profenophos + cypermethrin 44 EC (0.044 %) were effective for lowering bud borer infestation as well as Karanj oil 0.03% found least effective. In another study, profenophos (0.075%), chlorpyriphos (0.05%) and Bt @ 2g/l were found effective in reducing the damage of bud borer as compared to control (Anon., 2019b).

There was highest yield of 16.87 t/ha in profenophos 40% + cypermethrin 4% (T_7) comparable with Azadirachtin (2 ml/l) (T_4) and Bt (T_1) reported higher yield of 15.82 and 15.53 t/ha, respectively. The lowest fruit yield of 12.47 t/ha was observed in control (T_8). In ICBR, the higher ratio of 9.95 was estimated in profenophos 40% + cypermethrin 4% (T_7), after that in Azadirachtin (2 ml/l) (T_4), Azadirachtin (1 ml/l) (T_5) and Bt (T_1) with 1.30, 1.21 and 1.10 ICBR, respectively over control. Earlier, Ghirtlahre *et al.* (2015) reported *B. thuringiensis* 5 WP (0.0075%) and profenophos + cypermethrin 0.044% were given the highest fruit yield of sapota with C:B ratio and lower in Karanj oil.

The current findings revealed that Kalipatti and DHS-1 recorded higher damage in bud and flower due to bud borer and lower in PKM-1 and CO-3. Among spacing, the higher damage was recorded under high density plantation than normal spacing in both seasons. The infestation level was maximum during summer (February-May) as compared to winter (October-January) under both plantations. Regarding management of bud borer, though standard check profenophos 40% + cypermethrin 4% was found effective, but Azadirachtin 10000 ppm @ 2 ml/l and Bt (1 x 10^{11} CFU/g) @ 2 g/lit were also reduced the bud borer infestation after four sprays and exhibited higher fruit yield. The other biopesticide and botanical *viz.*, *B. Bassiana* (1 × 10^8 CFU/g) @ 4 g/lit and Azadirachtin 10000 ppm @ 1 ml/l were moderately effective against bud borer. The biopesticides and botanicals showed their higher efficacy at 5th and 7th day after application of 3rd and 4th spray.

ACKNOWLEDGEMENT

The authors are thankful to Director of Research and Dean P.G. Studies; The Principal, N.M.C.A. and Professor and Head, Department of Entomology, N.M.C.A., N.A.U., Navsari as well as Associate Research Scientist, ICAR-AICRP on Fruits, Fruit Research Station, N.A.U., Gandevi for providing all the funds and necessary germplasm facilities.

REFERENCES

Anonymous. 2001. Annual Report 2000-01. All India Coordinated Research Project on Tropical Fruits. Fruit Research Station, NAU, Gandevi. pp: 44-53.

Anonymous. 2019a. Annual Research Report 2018-19. 15th Plant Protection Sub-Committee (PPSC), Fruit Research Station, NAU, Gandevi. pp: 21-22.

Anonymous. 2019b. Research Report 2019. ICAR-All India Coordinated Research Project (AICRP) on Fruits, ICAR-IIHR, Bengaluru (Karnataka). pp: 234-236.

Anonymous. 2020. Annual Research Report 2019-20. 16th Plant Protection Sub-Committee (PPSC), Fruit Research Station, NAU, Gandevi. pp: 23-24.

Bisane, K.D. 2018. Bud borer complex and yield loss in sapota. *Indian Journal of Entomology*, **80** (3): 942-947.

Bisane, K.D. 2020. Screening sapota varieties against bud borer (*Anarsia achrasella* Bradley) under South Gujarat condition. *Indian Journal of Plant Genetic Resources*, **33**(3): 347-351.

Bisane, K.D. and Naik, B.M. 2016. Varietal performance of sapota against bud and seed boring insect pests under south Gujarat condition. *International Journal of Tropical Agriculture,* **34** (5): 1208-1209.

Bisane, K.D. and Naik, B.M. 2019. Consequences of ecological factors and crop phonological stages on seasonal incidence of bud borer, *Anarsia achrasella* Bradley on sapota. *Journal of Entomological Research*, **43** (3): 295-300.

Bisane, K.D., Dhane, A. S., Inulandi, S., Singh, Sandeep and Patil, Prakas. 2018. Insect pest of sapota in India - Monograph. Pub: ICAR-AICRP (Fruits), ICAR-IIHR, Bengaluru (Karnataka). pp: 1-88.

Ghirtlahre, S.K., Sahu, C.M., Nirala, Y.P.S., Kerketta, A. and Paikra K. L. 2015. Bio-efficacy of different insecticides against sapota bud worm, *Anarsia achrasella* (Lepidoptera: Gelechidae). *International Journal of Tropical Agriculture*, **33**(2): 537-540.

Khambhu, C.V. and Bisane, K.D. 2017. Seasonal occurrence of chiku moth (*Nephoteryx eugraphella* Ragonot) and bud borer (*Anarsia achrasella* Bradley) on sapota. *Entomon*, **42** (3): 207-213.

Shinde, B.D., Desai, B.G., Malshe, K.V., Dahiphale, A.V. and Sable, Y.R. 2010. Evaluation of botanicals, biopesticides and newer insecticides against sapota bud borer (*Anarsia achrasella* Bradley). *Pestology*, **34** (9): 32-34

Suryavanshi, S.S. and Patel, B.R. 2009. Evaluation of different insecticides against sapota bud borer, *Anarsia achrasella* Bradley. *Karnataka Journal of Agricultural Sciences*, **22** (3): 722-723.

Thumar, R.K., Borad, P.K. and Parmar, D. J. 2012. Management of bud borer, *Anarsia achrasella* Bradley on sapota, *Manilkara achras* (Miller). *Pest Management in Horticultural Ecosystem*, **18** (1): 100-102.

Vaja, A.S., Virani, V.R., Chudasama, K.A. and Dhandge, S.R. 2018. Varietal screening of sapota against insect pest complex. *International Journal of Current Microbiology and Applied Sci*ence, **7** (11): 440-445.

Vijayaraghavendra, R. 2014. Studies on major insect pests of sapota with special reference to sapota fruit borer, *Phycita erythrolophia* Hampson and its management. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, Bangalore (Karnataka).

MS Recieved -24 April 2021
MS Accepted 27 May 2021