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Impact of Integrated Pest Management Practices on Fruit fly and Fruit Borers in Guava cv. Taiwan White

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ABSTRACT: Among guava cultivars, Taiwan guava is the world's premier cultivar which can produce all year round. The nutritional content and yield of the guava is affected by more number of insect pests like mostly fruit fly and fruit borers. Due to the usage of vast chemicals, the insects are developing resistance against it and these chemicals sprayed are having an adverse effect on natural enemies and environment. So, here we implemented Integrated Pest Management practices which is free of toxic chemical spray against fruit fly and fruit borers and studied the impact of these practices against fruit fly and fruit borers. The experiment was conducted in established guava orchard of Dr. Y.S.R. Horticultural University, Andhra Pradesh during 2019-2020. The observations on fruit fly and fruit borers in Integrated Pest Management plot and control plot are taken on weekly intervals. The results shown the mean population of fruit fly maggots was 5.79 ± 1.17 per fruit in Integrated Pest Management plot, whereas in the control plot it was 11.31 ± 4.14 per fruit. The maximum mean fruit infestation per cent was recorded in control plot with 35.5 ± 13.95 per cent which was 42.7 per cent higher than in Integrated Pest Management plot with 14.01 ± 2.09 per cent. Lowest number larvae of *Conogethes punctiferalis* (1.04 ± 0.30 larvae per tree) and *Deudorix isocrates* (1.07 + 0.38 larvae per tree) were recorded in IPM plot with whereas, significantly high number of fruit borer larvae was recorded in control plot.

Keywords: fruit fly, fruit borers, IPM Plot, Control Plot and guava *cv.* Taiwan white.

INTRODUCTION

Guava fruit is a rich source of vitamin C, pectin, dietary fiber, iron, manganese, calcium, folic acid, potassium and phosphorus with high antioxidant properties, nutritive and medicinal values. The common guava *Psidium guajava* (lemon guava, apple guava) is a small tree in the myrtle family (Myrtaceae), native to Mexico, Central America. It is universally called as "the apple of the tropics" or "poor man's fruit" and is one of the most important commercial fruits in India after mango, banana and citrus. Taiwanese guava was introduced from Taiwan. It is best to plant grafted seedling for early harvest. Grafted tree has a short, solid tree trunk and forms branches early. First year fruits can weigh from 250 to 300g per fruit. Fruit has light green skin when ripening. It is brittle, has few seeds and sweet taste. The tree bears two harvests of fruits per year: the first harvest is from March to April; the second harvest is from July to August. Originally Taiwan had a large variety of natural guava, and with the import of foreign guava varieties since 1915, there has been much research and experience in the production of excellent and hardy guava throughout Taiwan. The guava has a very high crop yields with the peak of production falling between November and February. Taiwan's pomiculture experience with guava involves many varieties, it is most famous for its crisp texture and sweet taste that melts in your mouth also referred to as the full moon" the pear guava is remarkable for its thick but crispy flesh with flavorful aromas; the white guava with its clear and shiny peel. There is a vast pest load in Taiwan guava, which is affecting the quality and yield of guava. Therefore, the

farmers are applying various insecticides which are very toxic to natural enemies that reduce the pest population naturally. Continuous sanitation practices the fruit fall reduced to 10.24, 7.04, and 8.39 % in guava, citrus and mango orchards, respectively (Abbas *et al.,* 2020). To combat the deleterious effects of synthetic chemicals, the best alternative in managing the guava pests by using diverse IPM components *viz.,* collection and destruction of infested fruits, raking or ploughing the soil, bagging of fruits, application of *Metarrhizium anisopliae* to the soil, installation of methyl eugenol traps and need based application of insecticides. Plant extracts *Azadirachta indica* and *Citrullus colocynthis* proved better as they reduced pupal population 14.53 and 10.74, 9.87 and 2.85, 7.20 and 2.27 % in guava, citrus and mango orchards, respectively. Similarly, reduced trend was found in % fruit infestation by 19.41 and 10.29, 15.51 and 10.77, 5.84 and 4.80 % in guava, citrus and mango orchards, respectively after 2nd spray. (Abbas *et al.,* 2020). Makhmoor and Singh (1997) stated that soil raking in guava orchard once a day, once in three days, and at weekly intervals, resulted in 80, 70, and 43 per cent pupal mortality of fruit fly, respectively. *Metarhizium anisopliae* gave higher mortality reaching 94.4 per cent mortality in males and 76.8 per cent in females of *Bactrocera dorsalis* (Mahmoud, 2009). The significantly minimum fruit fly infested fruits (9.94 %) was noted in 15th September pruning guava plants, which was at par with 15th August pruning (11.87 %) guava plants and the maximum infestation (48.15 %) was noticed in un-pruned guava plants (Choudhary *et al.,* 2022). The use of nylon bags offered the highest protection against guava fruit fly and fruit borers up to 20 per cent infestation when in Taiwan guava (Montoya *et al.*, 2010). Hoeing under the tree canopy with collection of fallen fruits and spray of spinosad was found to be most effective reducing the average fruit fly infestation to 6% and 6.3% for the year 2013 and 2014 respectively and hoeing under tree canopy alone proved to be least effective with average fruit fly infestation 16.67% and 15.85% for the year 2013 and 2014. (Khan *et al.,* 2017). Maximum % reduction of fruit punctures were found as 14.41, 7.17 and 7.32 in guava, citrus and mango orchards, respectively with combined application of all components. (Abbas *et al.,* 2020). Hence, we implemented the IPM practices during this research against fruit fly and fruit borers of guava and studied their impact on them.

MATERIALS AND METHODS

Experiment was carried out in existing guava orchard at Dr. Y.S.R. Horticultural University in Venkataramannagudem, West Godavari District of Andhra Pradesh with cultivar of Taiwan white and plot size 1200 m^2 at spacing of 2 m × 2 m between rows and plants respectively during Mrig bahar. The details pertaining to integrated pest management practices obtained, observations recorded and statistical tools used during the course of this investigation is described in here under.

Treatment 1: Schedule of IPM practices in guava cv. Taiwan white:

1. Raking or ploughing the soil around the tree to expose resting stages of insect at three days interval from November 2019 to February 2020.
2. Regular collection and destruction of fallen and infested fruits.
3. Pruning of intermingling excessive branches to stop the infestation from one branch to other in the July – October 2019.
4. Soil application of *Metarrhizium anisopliae* @ 2 kg/acre to reduce the fruit flies at first week of November 2019.
5. Installation of light traps @ 1/ acre in guava field against lepidopteran pests at first week week of November 2019.
6. Erection of bird perches @ 15/acre in guava field at first week of November 2019.
7. Bagging of fruits with paper bags to avoid infestation of borers at monthly intervals from November 2019 to February 2020.
8. Installation of methyl eugenol pheromone traps @ 10 / acre at fruit development stage to control fruit flies [methyl eugenol (0.1%) + malathion (0.1%)] at monthly intervals from November 2019 to February 2020.
9. Need based spraying application of insecticide viz., NSKE 5% @ 3ml/lit, Neem oil @ 3 ml/lit, *Bacillus thuringiensis* @ 1 gm/lit and Spinosad @ 0.25ml/lit for the management of borer pests was carried out on the appearance of the pest and repeated at 15 days interval from November 2019 to February 2020.

Treatment 2: Control plot as an untreated plot without any management practices.

Number of fruit fly maggots per fruit:

The number of maggots in the infested fruits were recorded by dissecting the guava fruits.

Fruit infestation (%)

The percentage of fruit infestation was worked out with the help of following formula given by Abott (1925):

% infestation of fruit/plant

$$= \frac{\text{Number of infested fruits/plant}}{\text{Total number of fruits/plant}} \times 100$$

Number of fruit borer larvae per tree

Number of larvae per tree was taken from the five randomly selected trees in IPM plot and Control plot by counting the number of larvae in the infested fruits of each tree in both the plots and the average number of larvae per tree is taken for analysis from IPM and control plot.

Fruit infestation (%). The percentage of fruit infestation was worked out with the help of following formula given by Abott (1925):

% infestation of fruit/plant

$$= \frac{\text{Number of infested fruits/plant}}{\text{Total number of fruits/plant}} \times 100$$

Statistical analysis: The data obtained from IPM plot and Control plot was analyzed through Paired t-test to compare both the treatments (IPM and Control plot) in SPSS 2020 software. The meteorological data pertaining to rainfall, mean temperatures, relative humidity was recorded from Meteorological department in Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari, A.P.

RESULTS AND DISCUSSION

Effect of IPM practices on maggot population and infestation of guava fruit fly

The data presented in the Table 1 and Fig. 1, revealed that the number of maggots in fruits of guava cv. Taiwan white in IPM plot decreased significantly than the control plots. The mean number of maggots per infested fruit was found to be 5.79 ± 1.17 number per fruit in IPM plot of guava compared to that of control plot with 11.31 ± 4.14 number per fruit, which was 56.35 per cent higher than the IPM plots. There was a significant difference in number of maggots per fruit between IPM and control plots as per the t-statistical value depicted in the Table 2. The mean per cent fruit infestation in control plots of guava cv. Taiwan white was 35.5 ± 13.95 which was 42.70 per cent higher than in IPM plot with 14.01 ± 2.09 mean per cent fruit infestation (Table 1 and Fig. 2). The data in Table 2, represented that there was a significant difference in per cent fruit infestation recorded in between IPM and control plots of guava as per the t-statistical value.

Table 1: Infestation of *Bactrocera dorsalis* in IPM and control plots of guava cv. Taiwan white.

SMW	IPM plot		Control plot		PR% of No. of maggots in IPM over control	PR% of fruit infestation in IPM over control
	No. of maggots/ fruit	Fruit Infestation %	No. of maggots/ fruit	Fruit Infestation %		
44	3.20	10.81	3.80	12.90	15.79	16.20
45	3.80	10.53	4.80	15.04	20.83	29.99
46	4.20	12.20	5.90	19.70	28.81	38.07
47	5.80	15.56	6.90	21.79	15.94	28.59
48	6.40	16.67	7.86	25.64	18.58	34.98
49	7.00	17.31	8.64	27.80	18.98	37.73
50	6.00	16.98	10.06	29.99	40.35	43.38
51	5.60	15.09	10.90	32.51	48.62	53.58
52	5.40	14.29	11.76	35.00	54.08	59.17
1	4.80	12.28	12.80	35.38	62.50	65.29
2	5.80	13.11	13.00	36.92	55.38	64.49
3	6.20	14.52	13.70	38.79	54.74	62.56
4	7.20	16.13	14.50	41.67	50.34	61.29
5	6.60	13.56	14.80	45.47	55.41	70.17
6	7.60	15.52	15.75	48.79	60.51	68.19
7	6.40	13.46	15.93	55.90	59.82	75.92
8	5.80	12.00	16.02	56.99	63.80	78.94
9	6.40	12.24	16.50	58.78	61.21	79.18
Mean ± S.D	5.79 ±1.17	14.01 + 2.09	11.31 ±4.14	35.5 + 13.95	43.65	57.30

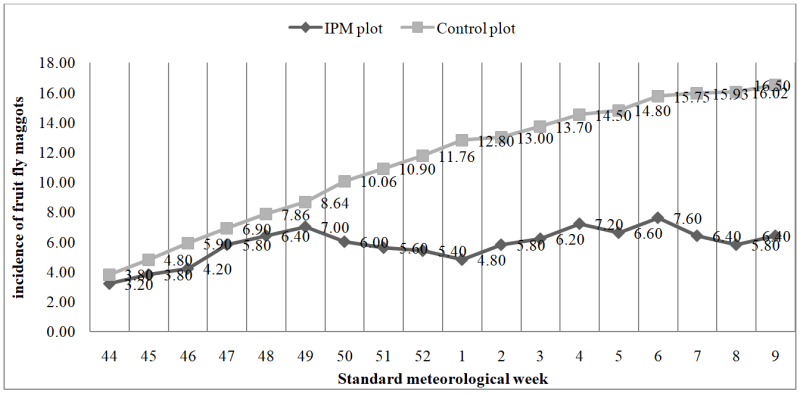

Fig. 1. Fruit fly, *Bactrocera dorsalis* (maggot population) during different standard weeks in IPM and control plots of guava cv. Taiwan white (2019 – 2020).

The present findings are in agreement with the observation made by Verghese *et al.* (2002) who reported reduction in fruit fly population due to ploughing or raking the area under and between trees during summer and early harvest of mature fruits. Correspondingly, Makhmoor and Singh (1997); Morera-Montoya *et al*. (2010), Mondal *et al.* (2015) described that bagging of the fruits prevents oviposition by fruit flies. Mahmoud (2009) reported that *M. anisopliae* resulted in higher mortality reaching 94.4 per cent in males and 76.8 per cent in females in bioassay test of oriental fruit fly. Firake *et al*. (2013) indicated that raking the soil and application of *Metarrhizium anisopliae* @ 5 kg/ha to the soil underneath the tree canopy reduced fruit fly infestation. Sookar *et al*. (2014) also reported that infection by *M. anisopliae* resulted in the reduction of the number of eggs produced by females of fruit fly. The use of methyl eugenol traps stands as the most outstanding alternative for the management of fruit flies as it has olfactory and phago-stimulatory action to attracts the males of *B. dorsalis, B. correcta, B. zonata* was reported by Babu and Viraktamath (2003), Rajitha and Viraktamath (2006), Dale and Patel (2010), Sharma *et al*. (2016), Bagheri *et al*. (2017). Efficacy of neem, *Azadirachta indica* against guava fruit fly, *B. dorsalis* was also put forth by Singh (2003), Agrawal *et al.* (2019) and Abbas *et al.,* (2020) who illustrated strong antifeedant, repellent, insect growth regulatory and sterility activity in fruit fly. Choudhary *et al.,* (2022) revealed that the significantly minimum fruit fly infested fruits (9.94 %) was noted in 15th September pruned guava plants, which was at par with 15th August pruned guava plants 11.87 % and the maximum infestation (48.15 %) was noticed in un-pruned guava plants.

Effect of IPM practices on population and infestation of guava fruit borers, *Conogethes punctiferalis* and *Deudorix isocrates*

The data given in the Table 2 and Fig. 3, revealed that the mean population of *C. punctiferalis* larvae was found to be lesser in IPM plot(1.04 ± 0.30 larvae per tree) when compared to that of control plot (3.25 ± 1.25 larvae per tree) which was 64.41 times more than the IPM plot of guava cv. Taiwan white. There exists significant difference in number of larvae per guava tree in IPM plots and control plots as per the t-statistical value depicted in the Table 4. The mean per cent fruit infestation was 8.08 ± 1.41 in IPM plot, while in control plot it was 23.66 ± 9.46 which was 60.17 per cent higher that of IPM plot (Table 3 and Fig. 4). Further, there was a significant difference in per cent fruit infestation in IPM and control plots as per the t-statistical value presented in Table 4.

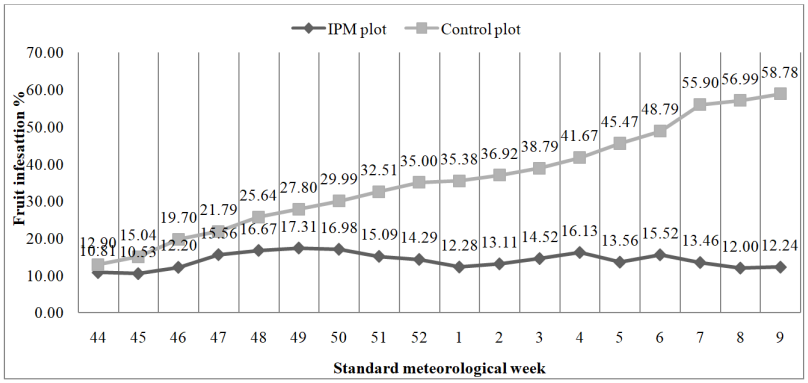

Fig. 2. Fruit fly, *Bactrocera dorsalis* (fruit infestation) during different standard weeks in IPM and control plots of guava cv. Taiwan white (2019 – 2020).

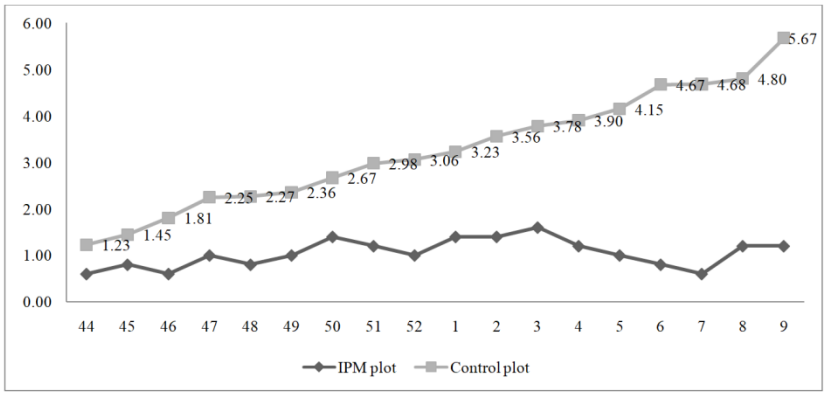

Fig. 3. Fruit borer, *Conogethes punctiferalis* (larval population) during different standard weeks in IPM and control plots of guava cv. Taiwan white (2019 – 2020).

Table 2: t- statistical values for testing of significance of *Bactrocera dorsalis* in IPM and control plots of guava

Treatments	Number of maggots per fruit in IPM and control plot in IPM and Control plot	Fruit infestation % in IPM and control plot
IPM (Mean ± S.D)	5.79 ±1.17	14.01 + 2.09
Control (Mean ± S.D)	11.31 ±4.14	35.5 + 13.95
t cal. Value	28.81	27.52
t tab. Value	2.11	2.11
P value	0.000 (Significant)	0.000 (Significant)

SMW – Standard meteorological week, IPM – Integrated pest management, PR - Per cent reduction

Table 3: Infestation of *Conogethes punctiferalis* in IPM and control plots of guava cv. Taiwan white.

SMW	IPM plot		Control plot		PR% of number of larvae in IPM over Control	PR% of fruit infesation in IPM over Control
	No. of larvae /tree	Fruit Infestation (%)	No. of larvae/ tree	Fruit Infestation (%)		
44	0.60	5.56	1.23	8.00	51.21	30.55
45	0.80	7.32	1.45	11.79	44.82	37.93
46	0.60	6.98	1.81	12.89	66.85	45.87
47	1.00	8.33	2.25	13.91	55.55	40.07
48	0.80	7.84	2.27	14.91	64.75	47.39
49	1.00	8.93	2.36	16.99	57.62	47.46
50	1.40	9.84	2.67	19.89	47.56	50.55
51	1.20	8.20	2.98	20.97	59.73	60.90
52	1.00	6.45	3.06	22.56	67.32	71.40
1	1.40	7.81	3.23	23.88	56.65	67.28
2	1.40	8.96	3.56	25.88	60.67	65.39
3	1.60	10.29	3.78	27.87	57.67	63.06
4	1.20	9.52	3.90	28.24	69.23	66.27
5	1.00	8.20	4.15	31.65	75.90	74.10
6	0.80	7.14	4.67	34.69	82.86	79.40
7	0.60	5.45	4.68	36.78	87.17	85.17
8	1.20	8.77	4.80	36.90	75.00	76.22
9	1.20	9.84	5.67	37.99	78.83	74.10
Mean±SD	1.04 + 0.3	8.08 ± 1.41	3.25 + 1.25	23.66 ± 9.46	64.41	60.17

Minimum number of *D. isocrates* larvae per tree were recorded in IPM plot compared to control plot of guava cv. Taiwan white (Table 5 and Fig. 5). The mean number of *D. isocrates* larvae was 1.07 ± 0.38 per tree in guava IPM plot which was 61.04 per cent less as compared to that of control plot (3.03 ± 1.28). Significant difference in number of larvae per tree was observed as per the t-statistical value given in the Table 6. The mean per cent fruit infestation in guava grown in IPM plot was 9.87 ± 2.12 per cent which was 57.52 per cent less than that of control plot with 25.52 ±7.94 per cent (Table 5 and Fig. 6). There exists a significant difference in per cent fruit infestation between IPM and control plot of guava as per the t-statistical value given in Table 6.

The above results are in confirmation with the findings of Montoya *et al.* (2010); Mondal *et al.* (2015) who confirmed that bagging of fruit reduced fruit borer damage in guava. Firake *et al*. (2013), Shimoda and Honda (2013) stated that collection and destruction of fruits and installing light traps resulted in reducing damage by fruit borer up to 20 per cent by attracting and trapping adults during night time. Elanchezhyana and Vinothkumar (2015) ascertained that neem had a antifeedant effect on guava fruit borer. Khan *et al.* (2016); Manikandan *et al*. (2016) reported that *Bacillus thuringiensis* exhibited the efficiency of 73.8 per cent mortality and effectively checked the resurgence of the guava fruit borer. Narayanamma (2013) reported that spraying with spinosad recorded less per cent damage by fruit borer and resulted in high yield in guava.

Table 4: t- statistical values for testing of significance of *Conogethes punctiferalis* in IPM and control plots of guava.

Treatments	Number of larvae in IPM and control plot	Fruit infestation (%)in IPM and control plot
IPM(Mean ± S.D)	1.04 + 0.3	8.08 + 1.41
Control(Mean ± S.D)	3.25 + 1.25	23.66 + 9.46
t cal.value	33.59	30.44
t tab.value	2.11	2.11
P value	0.000 (Significant)	0.000 (Significant)

Table 5: Infestation of *Duoderix isocrates* in IPM and control plot of guava cv. Taiwan white.

SMW	IPM plot		Control plot		PR% of number of larvae in IPM over Control	PR% of fruit infesation in IPM over Control
	No. of larvae /tree	Fruit Infestation (%)	No. of larvae/ tree	Fruit Infestation (%)		
44	0.40	5.71	0.67	8.65	40.29	33.94
45	0.60	8.11	1.37	12.98	56.20	37.53
46	0.80	9.76	1.45	15.99	44.82	38.98
47	0.80	9.09	1.81	18.77	55.80	51.55
48	1.20	11.76	2.10	19.90	42.85	40.87
49	1.00	10.00	2.20	20.91	54.54	52.16
50	1.20	11.11	2.60	22.99	53.84	51.66
51	1.20	10.71	2.90	25.00	58.62	57.14
52	1.40	11.86	3.13	25.42	55.27	53.33
1	1.60	13.11	3.46	27.99	53.75	53.14
2	1.40	11.11	3.98	30.23	64.82	63.24
3	1.80	13.64	4.30	32.48	58.13	58.01
4	1.40	10.61	4.78	33.79	70.71	68.60
5	1.20	9.52	4.98	34.50	75.90	72.39
6	1.00	8.93	4.99	34.78	79.95	74.33
7	0.80	8.00	3.65	33.62	78.08	76.20
8	0.80	8.33	3.30	32.12	75.75	74.05
9	0.60	6.38	2.90	29.24	79.31	78.16
Mean ± S.D	1.07 + 0.38	9.87 + 2.12	3.03 + 1.28	25.52 + 7.94	61.04	57.52

Table 6: t- statistical values for testing of significance of *Duoderix isocrates* in IPM and control plots of guava.

Treatments	Number of larvae in IPM and control plot	Fruit infestation % in IPM an Control Plot
IPM(Mean ± S.D)	1.07 + 0.38	9.87 + 2.12
Control(Mean ± S.D)	3.03 + 1.28	25.52 + 7.94
t cal.value	32.32	36.91
t tab.value	2.11	2.11
P value	0.000 (Significant)	0.000 (Significant)

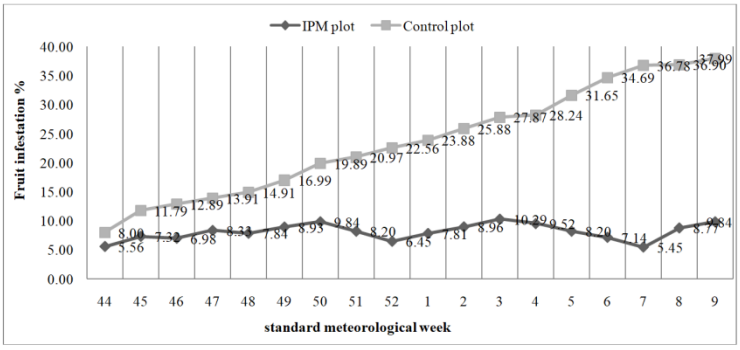

Fig. 4. Fruit borer, *Conogethes punctiferalis* (fruit infestation) during different standard weeks in IPM and control plots of guava cv. Taiwan white (2019 – 2020).

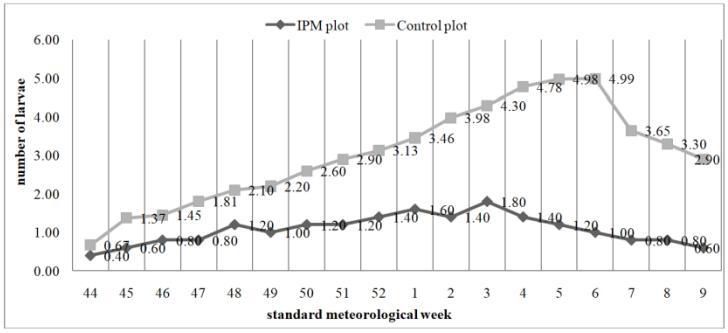

Fig. 5. Fruit borer, *Deudorix isocrates* (larval population) during different standard weeks in IPM and control plots of guava cv. Taiwan white (2019 – 2020)

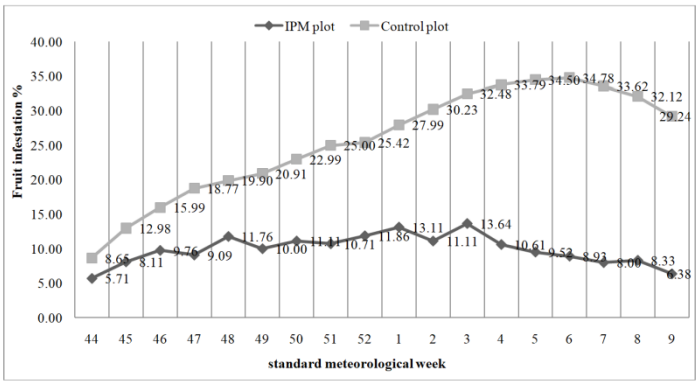

Fig. 6. Fruit borer, *Deudorix isocrates* (fruit infestation) during different standard weeks in IPM and control plots of guava cv. Taiwan white (2019 – 2020).

CONCLUSION

The studies on the influence of IPM practices on the insect pests of guava cv. Taiwan white revealed that the mean population of fruit fly (*B. dorsalis*) maggots was 5.79 ± 1.17 per fruit in IPM plot, whereas in the control plot it was 11.31 ± 4.14 per fruit. The maximum mean fruit infestation per cent was recorded in control plot with 35.5 ± 13.95 per cent followed which was 42.70 per cent higher than in IPM plot with 14.01 ± 2.09 per cent. The lowest number of *C. punctiferalis* larvae were recorded in IPM plot with 1.04 ± 0.30 number whereas, more number of larvae was recorded in control plot with 3.25 ± 1.25. The fruit infestation by *C. punctiferalis* was highest in control plot with 23.66 ± 9.46 per cent. The number of *D. isocrates* larvae per tree in IPM plot was recorded lowest with 1.07 ± 0.38 while, in control plot it was 3.03 ± 1.28. The minimum per cent fruit damage by *D. isocrates* was recorded in fruits grown in IPM plots with 9.87 ± 2.12 per cent whereas, in control plot it was 25.52 ± 7.94 per cent. In the present investigation, the reduction in number fruit infestation by fruit fly and fruit borers in IPM plots in contrast to control plots was mainly accredited to adoption of various IPM practices *viz.,* collection and destruction of infested fruits, raking or ploughing the soil, bagging of fruits, application of *Metarrhizium anisopliae* to the soil, installation of methyl eugenol traps, light trap, erection of bird perch and need based application of bio agents and insecticides *viz.,* NSKE 5% @ 3ml/lit, Neem oil @ 3 ml/L, *B. thuringiensis* @ 1 g/L at SMW, Spinosad @ 0.25ml/L. To sum up, guava cv. Taiwan white cultivated in IPM plot was found with minimum pest load and crop damage with higher marketable yield and better fruit quality which are safer for consumption and maintaining ecological balance.

FUTURE SCOPE

1. Genomic studies of identified fruit fly and fruit borer strains can be studied and Sterile Insect Technology can be applied to control it.
2. Combined effect of botanicals and newer insecticides can be studied against these pests of guava

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