Pest Management in Horticultural Ecosystems
Vol. 29, No.1 pp 26-33 (2023)
DOI Number:10.5958/0974-4541.2023.00004.8

Bio-intensive integrated management of fruit piercing moths in Citrus

SANDEEP SINGH[1*], RAKESH KUMAR SHARMA[2], RAJWINDER KAUR SANDHU[1], SUMANJIT KAUR[3] and MASRAT SIRAJ[1]

[1]Department of Fruit Science, Punjab Agricultural University, Ludhiana, 141004, Punjab, India

[2]Farm Advisory Service Centre, Gangian, Hoshiarpur, 144205, Punjab, India

[3]MS Randhawa Fruit Research Station, Gangian, Hoshiarpur, 144205, Punjab, India

***E-mail:** sandeep_pau.1974@pau.edu*

ABSTRACT: Fruit piercing moths, *Eudocima* spp. and *Acanthodelta janata* L. affect both quality and quantity of the citrus fruits. Field studies were carried out during 2020 and 2021 to evaluate IPM modules against fruit piercing moths. Mean fruit damage was significantly low in trees covered with nets, followed by treatment with Horticulture Mineral Oils (Arbofine HMO, HP HMO and MAK HMO) followed by PAU Homemade Neem extract and PAU Homemade Dharek extract. Use of Poison bait traps @ 20 traps/acre also resulted in less fruit damage when compared to control. The average fruit yield was higher (36.7q/acre & 38.1q/acre) in netted trees followed by spraying of HMO's (35.6q/acre & 38.q/acre) during 2020 and 2021. Cumulative effects of applying all IPM components resulted in benefit-cost ratio of 9:1. These recommended IPM tools can be adopted by farmers as they are easily available, effective and economical.

Keywords: Citrus, fruit-piercing moths, IPM, Horticulture mineral oil, submontaneous zone

INTRODUCTION

Citrus is grown commercially throughout the India and comes third after mango and banana. In India, the estimated area under citrus is 973 thousand ha with an annual production of 15 million MT (Statista, 2022). In Punjab, citrus fruits are occupying an area of 50.195 thousand hectares with production of 1223027 metric tonnes (Thind, 2021). The area under citrus is declining especially under Kinnow mandarin inspite of prolific bearer with excellent fruit quality. This could be due to lower market price and secondly, the production is bogged down by different biotic and abiotic stresses. Among biotic stress, insect pest are important factors. Citrus fruits are attacked by various insect pests from time to time, which not only cause damage to fruits but also act as vector of many diseases, thus leading to huge economic losses to farmers in Punjab. There have been reports of about 250 species of insect pests in India which infest citrus. In Punjab, only 34 insect and mite species are active (Singh *et al.,* 2021; Singh *et al.,* 2020; Sharma *et al.,* 2011). Among these, fruit-piercing moths (FPMs), *Eudocima materna* (Linnaeus), *Eudocima fullonia* (Clerck), *Acanthodelta janata* (Linnaeus) and other species are among the potentially serious pests of citrus and occurs all over the country causing medium to high level of infestation (Singh *et al*., 2020; Singh *et al.,* 2021).

Fruit piercing moths are serious pests of different fruit crops throughout tropical and subtropical belt from Africa through Southeast Asia and Australia to the Pacific Islands (Leong and Kueh, 2011). These moths are reported on citrus, carambola, guava, mango, papaya, banana, fig, kiwifruit etc. About 86 species of fruit piercing moths are reported from Thailand. The most important species is *Eudocima phalonia* (L.) (Lepidoptera: Noctuidae), a species widely distributed in Africa, the Indian Islands, Asia, Australasia and the Pacific Islands (Leong and Kueh, 2011). These pests are sporadic in nature but can cause serious damage to ripe and ripening citrus fruits particularly in sub-mountainous zones of District Hoshiarpur, Punjab, India (Singh *et al.,* 2016). During 2004 to 2021, about 10 to 90 per cent fruit damage have been observed in Citrus (Kinnow, Daisy, sweet oranges, grapefruits and W. Murcott) orchards in the *Kandi* belt of District Hoshiarpur, Punjab, India. The damage by FPM *Eudocima* species alone sums up to 40% to 100% of the production on pomegranate, citrus in southern and northern India thus causing heavy loss to farmers (Singh *et al.,* 2012).

Unlike the other lepidopteron pests where larval stages are harmful, in fruit sucking moths adults are destructive due to their feeding habit on matured fruits. The larvae of these insects prefer to feed on the leaves of unrelated trees, shrubs and weeds often located well away from the adult feeding places, mostly belonging to the family Menispermaceae (Ramkumar *et al*., 2010). Larvae of *E.*

materna feed on leaves of creeper, *Tinospora cardifolia* (Giloe) (Fig. 1A) whereas larvae of *A. janata* feed on leaves of castor (*Ricinus communis*) (Fig. 1B).

Upon emergence, the adult moth swarm in large numbers from the adjoining areas/bushes/weeds, during September-October, towards the odour released by the ripening fruits, particularly fallen fruits. Adult moths suck the juice from ripe fruits (Fig. 1C and 1D), piercing the fruits with their strongly sclerotized proboscis with sharp spines, with which they macerate the pulp and suck the juice (Robinson *et al*., 2012). A circular pinhole like spot appears at the feeding site (Fig. 1H). Later on, the area around the damaged portion turns yellowish-brown (Fig. 1E, 1F, 1G). As many as 1-16 holes have been recorded on a single fruit of Kinnow mandarin (Singh *et al.,* 2012). As a result, the area around the holes becomes soft which results in fungal and bacterial infection. On squeezing such fruits, jet of fermented juice comes out from each hole. Furthermore, secondary invasions by micro-organisms spread into damaged tissues causing rot and premature fruit fall (Magar, 2012). Their peak activity period is recorded from September-October on Citrus in northern India.

The damage caused by fruit piercing moths in the *Kandi* belt of district Hoshiarpur, Punjab over the years ranged from 20 to 90 per cent. During a normal year, damage to fruit crops caused by this moth are less than 30 per cent, but the species can be highly destructive, up to 100%, when outbreak occurs as reported by Leroy *et al.,* (2021). Singh *et al.* (2012) also reported that the damage caused by fruit piercing moths, *Eudocima* spp. in citrus orchards in Punjab ranged from 15-100% depending on severity of infestation. With increasing incidence of fruit piercing moths, there is need to adopt IPM model for management of this pest and to get better fruit yield.

These moths are very difficult to control as their egg, larval and pupa stages are in/on the weeds/creepers and thus they escape from any management practices. Adult moths cause damage to fruits after sunset and return to adjoining area after a few hours of feeding (Chaudhari, 2020). Practically, no stage of these moths is available in the orchards for control. Farmers bear heavy losses due to severe fruit drop and also spray applications are leading to a heavy increase in their expenditure. Furthermore, application of insecticides at ripening stage is not desirable. Eco friendly management tactics can be applied as an alternative to the use of insecticides as they have been shown to be effective for pest management (Leroy *et al.,* 2021). To overcome these hurdles in control of fruit piercing moths, the present study was taken up to explore the feasibility of IPM module devised for eco-friendly management of fruit piercing moths in citrus including cultural practices, HMOs, botanicals, poison bait traps, netting and light traps.

MATERIALS AND METHODS

***Location*:** Studies were conducted at the village Gardhiwala, District Hoshiarpur, Punjab (India) (31.7325°N, 75.7506°E) during 2020 and 2021 in Citrus orchard (variety Daisy Tangerine) during August to November.

Treatments: IPM module consisting of netting of entire row of trees, application of PAU Homemade Neem extract and PAU Homemade Dharek extract @ 12 ml/l water, spray of three horticulture mineral oils (HMOs) viz., HP HMO, Arbofine HMO and MAK HMO @ 12.5 ml/l water, Poison bait traps @ 20 per acre was imposed in citrus orchard during the 1st week of August with the initiation of colour break stage of fruits; destruction of wild weeds and creepers, especially *Tinospora cardifolia* (*Giloe*) and castor (*rind*) in and around the orchards; disposal of fallen fruits as they attract the moths; creating smoke in the orchards after sunset; burning *Mashals* in the orchards after sunset and manual collection and killing of moths attracted towards the *Mashals;* fixing of lights traps to attract the moths; For each treatment 20 trees per row were selected representing 3 replications and in control, 20 trees were kept unsprayed.

Preparation of Light Traps

100 W bulb was installed on a five litre plastic container and 200 ml burned diesel oil was placed at the bottom of container. 200 meter electric wire was used to fix 20 traps.

Preparation of Poison Bait Traps

Malathion 0.05% @ 10 ml + Citrus fruit juice 100 ml + jaggery 100 g in 900 ml water were mixed to make final volume 1 litre.

Preparation of PAU Homemade Neem extract:

PAU Homemade Neem Extract was prepared by boiling 4.0 kg terminal parts of the shoots of neem trees including leaves, green branches and fruits in 10 L of water for 30 minutes. This material was then filtered through muslin cloth to get the desired plant extracts and used for spraying as per doses recommended in the treatments.

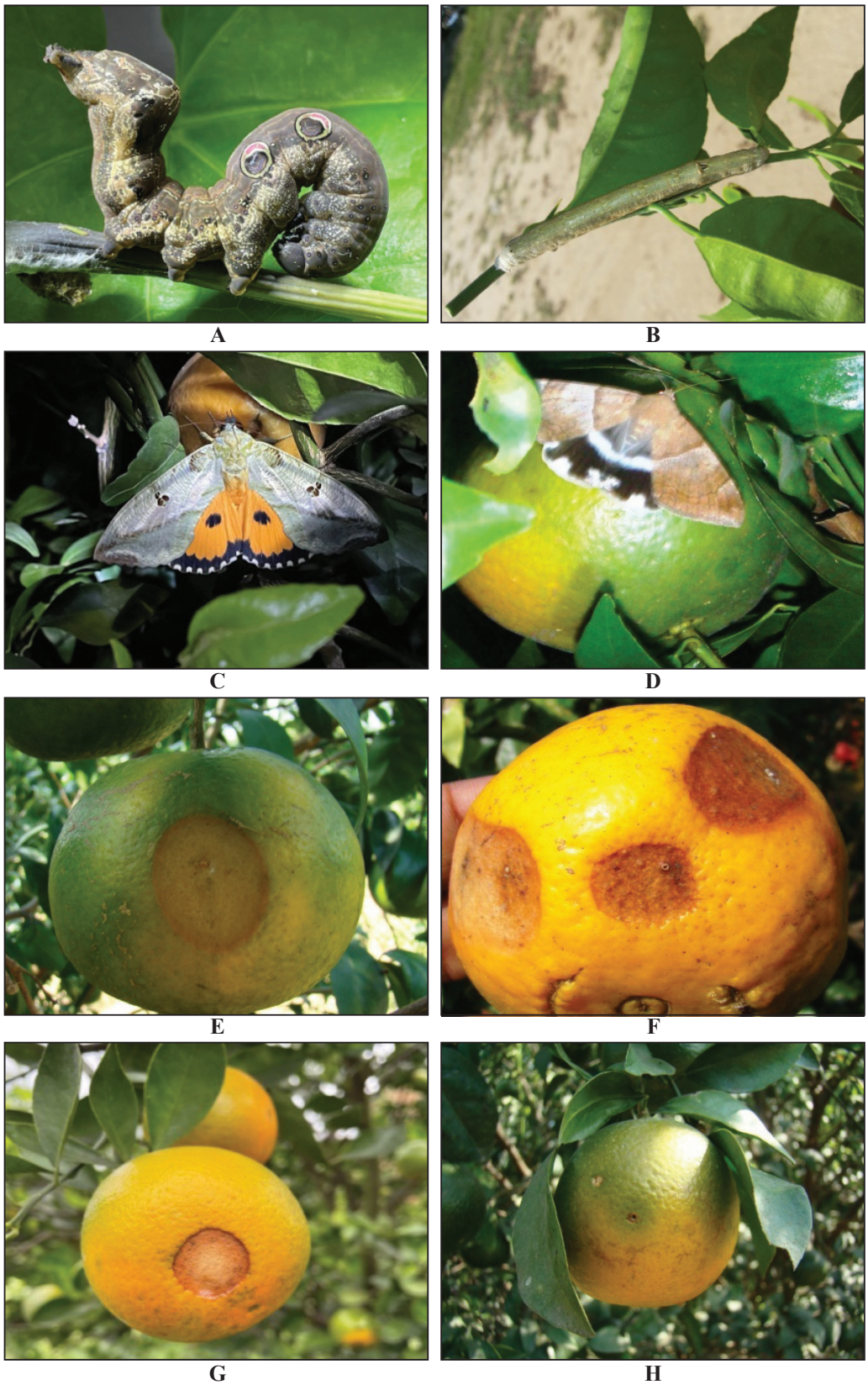

Fig 1. A. Larva of *Eudocima materna on* Giloe leaf; B. Larva of *Acanthodelta janata*; B. Adult of *Eudocima materna* on Kinnow fruit; D. Adult of *Acanthodelta janata* on Kinnow fruit; E. Damage on Kinnow fruit; F. Damage on Kinnow fruit; G. Damage on Daisy fruit; H. Hole on Kinnow fruit

Table 1. Evaluation of treatments against fruit sucking moths on Citrus Cv. Daisy at Village Garhdiwala, district Hoshiarpur during 2020

Treatment	Damaged fruits* (%)							
	Sep. 9	Sep. 16	Sep. 23	Sep. 30	Oct 7	Oct 14	Oct 22	Mean
Netting of trees **(Entire row of 20 trees)**	31.0 (33.9)	32.5 (34.6)	33.0 (35.4)	34.0 (35.6)	36.0 (37.0)	37.5 (37.6)	41.0 (39.9)	35.0 (36.4)
PAU Homemade Neem Extract @ 12 ml/l	40.0 (38.9)	41.6 (40.2)	43.2 (41.3)	45.0 (41.9)	46.5 (42.9)	48.0 (44.2)	50.0 (45.7)	44.9 (41.9)
PAU Homemade Dharek Extract @ 12 ml/l	40.0 (38.9)	41.0 (39.9)	44.0 (41.2)	46.7 (42.9)	48.1 (44.2)	50.5 (45.8)	52.0 (45.9)	46.0 (42.6)
Arbofine HMO @ 12.5 ml/l	32.0 (34.6)	33.0 (35.4)	35.5 (36.8)	36.0 (37.0)	38.5 (38.6)	39.0 (38.8)	40.0 (38.9)	36.3 (37.2)
HP HMO @ 12.5 ml/l	35.0 (36.4)	35.5 (36.8)	37.0 (37.4)	38.0 (38.4)	38.0 (38.4)	40.0 (38.9)	43.0 (41.2)	38.1 (38.4)
MAK HMO @ 12.5 ml/l	35.0 (36.4)	36.0 (37.0)	37.2 (37.4)	38.0 (38.4)	40.0 (38.9)	41.0 (39.9)	41.5 (40.1)	38.4 (38.9)
Poison Bait traps @ 20 traps/ acre	46.0 (42.6)	47.0 (43.4)	49.8 (45.4)	52.0 (45.9)	52.5 (45.9)	53.0 (46.8)	55.0 (48.3)	50.8 (45.8)
Control	73.0 (64.7)	80.0 (67.5)	84.3 (69.1)	85.0 (69.6)	86.4 (70.1)	88.0 (70.9)	90.0 (71.9)	83.8 (69.2)
CD (p=0.05)	**(8.4)**	**(6.9)**	**(6.1)**	**(5.8)**	**(5.5)**	**(5.1)**	**(4.6)**	**(5.9)**

*Figures in parentheses are the means of arc sine transformations; Mean of 20 trees

Preparation of PAU Homemade Dharek extract

PAU Homemade Dharek Extract was prepared by boiling 4.0 kg of green branches, leaves and fruits of dharek tree were boiled in 10 liters of water for 30 minutes. Filter the material through muslin cloth and use the filtrate as spray.

Observation

Observations on damaged fruits (%) due to fruit piercing moths before and after the treatments were recorded at weekly intervals. Yield data of each treatment and control orchards were also recorded.

Data collection and analysis

The data thus collected were subjected to statistical analysis using analysis of variance (ANOVA) of Statistical Package for Social Science (SPSS) to know the significance of differences in per cent damage among treatments for their efficacies. The data on per cent fruit damage were transformed into arc sine root transformation in a Randomized Block Design before statistical analysis (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The effect of different treatments on the fruit damage by fruit piercing moths during 2020 and 2021 are presented in Table 1 and Table 2. The results revealed that all the treatments were significantly effective in reducing fruit damage as compared to control.

During 2020, fruit damage was recorded lowest (35.0% damaged fruits) in the rows covered with nets, thereby protected 65 per cent of fruits (Table 1). The next best treatment was application of horticulture mineral oils (HMOs) with Arbofine HMO protecting the fruits with only 36.3% fruit damage while HP HMO and MAK HMO managed the fruits from fruit sucking moths with 38.1% and 38.4 % fruit damage, respectively. Furthermore, there were 44.90 and 46.04 percent damaged fruits recorded in PAU homemade Neem extract and PAU homemade Dharek extract treatments, respectively. Placing of poisonous baits recorded significantly higher fruit damage (50.7%) followed by control with 83.8 % fruit damage as compared to other treatments.

During 2021, there was a significant decrease ($P \leq 0.05$) in the percent fruit damage caused by fruit piercing moths in treatment with netting of trees as evident from

Table 2. Evaluation of treatments against fruit sucking moths on Citrus Cv. Daisy at Village Garhdiwala, district Hoshiarpur during 2021

Treatments	Damaged fruits* (%)							
	Sep. 7	**Sep. 15**	**Sep. 22**	**Sep. 30**	**Oct 5**	**Oct 12**	**Oct 21**	**Mean**
Netting of trees **(Entire row of 20 trees)**	30.0 (33.3)	32.0 (34.6)	32.5 (34.6)	33.0 (35.4)	33.0 (35.4)	34.0 (35.6)	37.5 (37.6)	33.1 (35.4)
PAU Homemade Neem Extract @ 12 ml/l	38.0 (38.4)	40.5 (39.9)	41.0 (39.9)	43.2 (41.3)	44.3 (41.3)	45.0 (41.9)	45.5 (42.9)	42.5 (40.9)
PAU Homemade Dharek Extract @ 12 ml/l	41.0 (39.9)	42.0 (40.5)	42.5 (40.9)	45.5 (42.9)	46.5 (42.9)	47.0 (43.4)	47.0 (43.4)	44.5 (41.5)
Arbofine HMO @ 12.5 ml/l	32.0 (34.6)	33.0 (35.4)	33.5 (35.6)	34.0 (35.6)	34.0 (35.6)	35.5 (36.8)	36.0 (37.0)	34.0 (35.6)
HP HMO @ 12.5 ml/l	34.5 (36.2)	35.0 (36.4)	35.0 (36.4)	36.0 (37.0)	38.0 (38.4)	39.5 (39.2)	41.0 (39.9)	37.0 (37.4)
MAK HMO @ 12.5 ml/l	36.0 (37.0)	38.0 (38.7)	38.5 (38.6)	39.0 (38.9)	40.0 (38.9)	40.0 (38.9)	42.0 (40.5)	39.1 (38.9)
Poison Bait traps @ 20 traps/ acre	48.0 (44.2)	50.5 (45.8)	50.5 (45.8)	53.0 (46.8)	53.5 (46.9)	55.0 (48.3)	56.5 (48.5)	52.4 (45.9)
Control	75.0 (61.3)	78.0 (63.8)	80.5 (66.3)	83.0 (66.3)	84.0 (68.7)	84.5 (69.4)	88.0 (70.9)	81.9 (66.7)
CD (p=0.05)	**(3.6)**	**(4.4)**	**(5.3)**	**(6.3)**	**(5.9)**	**(5.9)**	**(5.2)**	(6.5)

*Figures in parentheses are the means of arc sine √percentage transformations; Mean of 20 trees/ row

the results (33.1% damaged fruits) (Table 2). However, there was no significant difference in the percent fruit damage between HMO's treatment that ranged from 34.0-39.1 per cent followed by PAU homemade Neem extract (42.5%) and PAU homemade Dharek extract (44.5%). Up to 52.4 per cent damaged fruits were recorded in poison bait traps treatment while in control trees; damage was as high as 81.86 per cent.

The data on fruit yield showed that the fruit yield in all the treatments was significantly higher than the untreated control (Table 3). However, the highest fruit yield of daisy fruit (36.7 q/acre and 38.1q/acre) was realized in treatment with netting of trees which was at par with management of fruit piercing moths with spraying of Arbofine HMO (35.6q/acre and 38.0) during 2020 and 2021 respectively. It was followed by treatment of spraying HP HMO (34.3q/acre and 34.7q/acre) and MAK HMO (34.2q/acre and 33.3q/acre) followed by treatment with spraying of PAU homemade neem extract (27.1q/acre and 30.8q/acre) and PAU homemade dharek extract (26.6q/acre and 27.2q/acre) during 2020 and 2021. The lowest yield 8.7 q/acre and 8.9 q/acre was registered in untreated control plots, indicating immense damage potential of fruit piercing moths on daisy fruit during 2020 and 2021.

These studies are in line with findings of Bhumannavar and Viraktamath (2012) who reported that nylon nets of 1cm mesh extended on each orchard line or by tree remains a possible alternative for short term for the management of fruit piercing moths in pomegranate orchards in the south India and orange in the central India. It could help to protect crops from other pests too (birds, fruit bats or fruit flies). This method was great success in Australia and in American Samoa against *E. materna* and a number of secondary fruit-piercing pest moths in Japan. While protective nets have some advantages for small areas or isolated trees they require a considerable investment even if they can be used for several years.

Present results are in confirmation with the earlier studies, who reported that the fruit and non-fruit based baiting techniques were screened for trapping the fruit sucking moths *E. materna* in the guava field but this technique alone was not so successful (Kamala Jayanthi *et al*., 2009; Mallikarjun *et al.,* 2019). In a nocturnal lepidopteran like the FPMs, olfaction is one of the major means to locate food (Doreen, 2011). In the present study, the olfactory preferences of FPMs towards baits in the citrus orchard to lure them away from the main crop were studied thus lowering fruit damage. Repelling an insect is the recognition of an unpleasant or repulsive

molecule causing insect to move away from the host. The use of neem and dharek extracts was effective in reducing fruit damage by repelling these moths away from main host and these results are also confirmed by study of Kamala Jayanthi *et al.,* (2010) who studied the effect of neem oil (*Melia azedarach*, Meliaceae) on guava and pomegranate fruits which was able to repel moths such as *E. materna*. Horticulture mineral oil provide significant decrease in fruit damage as was observed in Malaysia where Horticulture mineral oils (at 0.35%) were sprayed weekly until the fruits were ripe and a decrease in the damages (ranging fruit damage from 4-21%) caused by *E. phalonia* as compared to control with more than 40% fruit damage was recorded in orange orchards (Leong and Kueh, 2011).

Observations of Robinson *et al*. (2012) are in conformation with our results where it was stressed to keep the light traps on from before dark until midnight because moths are not easily disturbed once feeding. Of the light sources that attract nocturnal insects, those that emit relatively large amounts of UV radiation (blue fluorescent lights, black lights, and mercury lamps) exert the strongest attraction (Cowan and Gries, 2009). Setting of light traps along with poison baiting with malathion 50 EC @ 10 ml + 100 g jaggery + 100 ml mandarin juice + 900 ml of water (two bottles containing poison bait/25-30 trees) will attract the adults of fruit sucking moths. Similarly, foliar application of neem oil @ 1 per cent or malathion 50 EC @2 ml at 10-15 days interval during fruit maturity till harvest provided good control of fruit piercing moths on Citrus (Singh *et al.,* 2016). Foliar application of NSKE 5 per cent or fish oil rosin soap 2 per cent or karanj oil 1 per cent or azadirachtin 1500 ppm and neem oil 1 per cent spray on trees at fruit maturity was effective against *Eudocima* spp. depicted in above studies (Singh *et al*., 2016).

The use of smoke in the pomegranate orchard after sunset as it repels the moths of *Eudocima* spp. and appears to be quite effective as it was also reported by (Balikai *et al.,* 2009) but the method is constrained by climatic conditions (wind, rain), which can sometimes seriously reduce its efficiency. In addition, it is effective for only one night and must therefore be repeated every night during the fruiting season and moths return to orchards as soon as the smoke dissipates. But it can be used in integral part with other methods of management of fruit piercing moths. Sherlin *et al.,* (2022) also reported similar results with use of IPM module i.e poison bait trap, light traps, smoke, removal of weeds etc. for management of *Eudocima* spp. in fruits.

Economic impact: In this study, the economic impact of different treatments was worked out by calculating total cost of treatment, total yield, gross returns, net income and net benefit of IPM module over control plot. Cost of treatments and B:C ratios are given in table 3. Netting of trees resulted in benefit of Rs. 5820.50, Neem and Dharek resulted in Rs. 7,057.75 and Rs 6335, respectively over control. HMOs also gave more returns such as Arbofine HMO: Rs. 9,369.50, HP HMO: Rs. 8,580 and MAK HMO: Rs. 8,326.80 over control. Similarly, poison bait traps gave benefit of Rs. 6,012 over control per row of 20 trees. Overall, with total expenditure of applying IPM module was Rs. 5704.63, benefit of Rs. 51, 501 was achieved. Although netting of trees is an expensive treatment but this treatment has proved to be very effective in preventing fruit piercing moth damage. Also, this will be very useful for small orchards and kitchen gardens.

On basis of findings of present study, following IPM module is proposed for management of fruit piercing moths

- Clean cultivation i.e. removal and destruction of weed hosts such as *Tinospora cardifolia* (*Giloe*) and castor (*rind*) in and around the orchards, as weed hosts act as oviposition substrate, resting place for adult moths and their larvae.
- Disposal of fallen fruits as they attract the moths.
- The moths are active during dusk so create smoke in the orchards after sunset as it deters the fruit sucking moths from orchards
- Cover the entire row of citrus trees with net of mesh size 1.2 mm from last week of August to avoid damage to fruits
- Spray PAU Homemade Neem extract and PAU Homemade Dharek extract @ 12 ml/ litre water at 7 days interval or spray horticulture mineral oils (HMOs) (HP HMO or Arbofine HMO or MAK HMO) @ 12.5 ml/litre water at 10 days interval starting from last week of August.
- Fix poison bait traps (Malathion 0.05% @ 10 ml + citrus juice 100 ml + jaggery 100 g + 900 ml water) in the orchards @20 traps/acre during 1st week of August with the initiation of colour break stage.
- Burning of *Mashals* in the orchards after sunset and manual collection and killing of moths attracted towards the *Mashals*
- Fix Homemade Light Traps using 100 W bulbs @ 20 traps/ acre during last week of August.

Table 3. Yield of Daisy fruits at Village Garhdiwala, district Hoshiarpur during 2020 and 2021

Treatment	2020		2021			
	No. of fruits per tree	Yield per acre (q)	No. of fruits per tree	Yield per acre (q)	Cost of treatment	B:C ratio
Netting of trees **(Entire row of 20 trees)**	98.8	36.7	102.0	38.1	4200	1.39
PAU Homemade Neem Extract @ 12 ml/l	72.9	27.1	83.7	30.8		
PAU Homemade Dharek Extract @ 12 ml/l	71.5	26.6	73.0	27.2	437.5	
Arbofine HMO @ 12.5 ml/l	95.7	35.6	101.7	38.0	406.25	21
HP HMO @ 12.5 ml/l	92.1	34.3	93.0	34.7	396.88	21
MAK HMO @ 12.5 ml/l	91.8	34.2	89.4	33.3	50.0	20
Poison Bait traps @ 20 traps/ acre	70.0	26.1	70.7	26.2	214.0	120
Control	23.4	8.7	24.0	8.9		
CD 5%	**2.52**	**1.55**	**0.51**	**0.12**		

Number of tree per acre= 200, average fruit weight = 186 g, average number of fruits per tree= 150

CONCLUSION

With increasing concern/risk of use of insecticides for management of fruit piercing moths in citrus, there is need to develop IPM module of pest control. Therefore, it could be concluded from above study that IPM module consisting of netting of trees followed by spraying of HMO's (Arbofine, HP HMO, MAK HMO) @ 12.5 ml/ l water at 10 days interval starting from last week of August or spraying of PAU Homemade Neem extract and PAU Homemade Dharek extract @ 12 ml/ l water at 7 days interval followed by fixing of poison bait traps in the orchards @ 20 traps/acre during 1st week of August was significant effective and economic, could be used for the management of fruit piercing moths in citrus. Besides this, various physical and mechanical control methods such as use of light traps (20 traps/acre), destruction of weeds and removal of damaged fruits from the orchards, use of smoke and mashals during dusk will also result in the tremendous reduction in fruit damage in citrus. These recommended IPM tools should be adopted by farmers because they are easily available, least cost and with maximum return. Pesticide residue free citrus fruits will be harvested which will increase the chances of export from Punjab, India.

ACKNOWLEDGEMENTS

The authors are thankful to Head, Department of Fruit Science, Punjab Agricultural University, Ludhiana, Punjab, India for providing necessary facilities to carry out this research work.

REFERENCES

Balikai, R. A., Kotikal, Y. K. and Prasanna, P. M. 2009. Status of pomegranate pests and their management strategies in India. *Acta horticulturae,* **890**: 569-583.

Bhumannavar, B. S. and Viraktamath, C. A. 2012. Biology, ecology and management of fruit piercing moths (Lepidoptera: Noctuidae). *Pest Management in Horticultural Ecosystems,* **18:1-18.**

Chaudhari, S. J. 2020. Fruit Sucking Moth: Ultimatum to Agricultural Crops. *Agriculture Mirror*: *Future India*, **7** (1): 19-23.

Cowan, T. and Gries, G. 2009. Ultraviolet and violet light: attractive orientation cues for the Indian meal moth, *Plodia interpunctella*. *Entomologia Experimentalis et Applicata*, **131**:148–158.

Doreen, S. B. 2011. Identification and analysis of olfactory receptors from the light brown apple

moth (*Epiphyas postvittana*). Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy in Biological Sciences, The University of Auckland, New Zealand.

Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for agricultural research, New York, Chichester, etc. Wiley, 2nd edition. pp.680.

Kamala Jayanthi, P. D., Abraham, V. and Nagaraju, D. K. 2009. Studies on feeding preference of adult fruit sucking moth, *Eudocima* (Othreis) *materna* (L.): A clue for devising trap- cropping strategies. *Pest Management in Horticultural Ecosystems*, **15** (2):107-113.

Kamala Jayanthi, P. D., Verghese, A., Nagaraju, D. K. and Jhansi Rani, B. 2010. Studies on the possibility of managing fruit sucking moth, *Eudocima* (Othreis) *materna* L. (Lepidoptera: Noctuidae) using feeding repellents. *Pest Management in Horticultural Ecosystems,* **16**: 124-130.

Leong, S. C. T. and Kueh, R. J. H. 2011. Seasonal abundance and suppression of fruit-piercing moth *Eudocima phalonia* (L.) in a citrus orchard in Sarawak. *Science World Journal*, **11**: 2330–2338.

Leroy, L., Mille, C. and Fogliani, B. 2021. The Common Fruit-Piercing Moth in the Pacific Region: A Survey of the Current State of a Significant Worldwide Economic Pest, *Eudocima phalonia* (Lepidoptera: Erebidae), with a Focus on New Caledonia, *Insects,* **12**: 1-25.

Magar, P. N. 2012. Fruit sucking moth: Primary and secondary fruit piercing moth species in Maharashtra, India. *Insect Environment*, **18**: 64-65.

Mallikarjun., Bhanu, K. R. M., Thippaiah, M., Raghavendra. A., Sharma, J. and Chakravarthy, A. K. 2019. Role of fruit volatiles and sex pheromone components in mate recognition in fruit piercing moth *Eudocima materna* Linnaeus (Lepidoptera: Erebidae). *Journal of Entomology and Zoology Studies*, **7**(3): 1381-1387.

Ramkumar, J., Swamiappan, M., Raguraman, S. and Sadasakthi, A. 2010. Larval host specificity and proboscis morphology of fruit piercing Moths. *Journal of Biopesticides*, **3**(2): 428-431.

Robinson, C. G., Pretorius, T., Moore, S. D. and Hill, M. P. 2012. Monitoring attraction of fruit-feeding moths in citrus orchards to different fruit baits in the Eastern Cape Province, South Africa. *South African Fruit Journal,* **2**: 87-92.

Sharma, D. R., Singh, S., Arora, P. K. and Bal, S. K. 2011. Biodiversity of insect and mite pests in relation to climate change in Punjab. Crop Improvement (Special Issue). In: International conference on Preparing Agriculture for Climate Change, held at PAU, Ludhiana, India, 195.

Sherlin, R. B. B., Saranya, B., Ravi, M., Balakrisnan, N. and Ravi, G. 2022. Integrated management of fruit sucking moths. *Krishi Science – eMagazine for Agricultural Sciences*, **3**(1):28-30.

Singh, S., Rao, C. N., Deka, S., Sonalka, R. V., Datkhile, R., Kadam, U. K., Rani, U., Sarada, G., Kaur, G. and Patil, P. 2016. Insect and mite pests of Citrus in India-Monograph. ICAR-AICRP on Fruits, IIHR, Bengaluru, 114.

Singh, S., Reddy, P. V. R. and Deka, S. 2020. Sucking pests of Citrus. In (Omkar, Ed). *Sucking Pests of Crops*. Springer Nature Singapore, 481-514.

Singh, S., Sandhu, R. K. and Aravind, N. A. 2020. Record of pestiferous land snail, *Macrochlamys indica* Godwin-Austen 1883 (Gastropoda: Ariophantidae) on citrus and guava plants in Punjab, India. *Records of the Zoological Survey of India*, **123**(3): 293-296.

Singh, S., Sandhu, R. K., Haldhar, S. M., Reddy, P. V. R., Deka, S., Reddy, D. S., Irulandi, S., Shete, M. H., George, A., Singh, V., Siraj, M. and Patil, P. 2021. Integrated pests management in citrus crop, pp.243-267 pp. In: *Pest Management in Dryland Horticultural Crops* (Eds: S.M. Haldhar and S.K. Maheshwari), Biotic Books, New Delhi (ISBN: 978-81-7622-491-8).

Singh, S., Sharma, D. R., Kular, J.S., Kahlon, G. S., Kaur, S. and Singh, A. 2012. Outbreak of fruit sucking moths on citrus in the sub-montaneous zone of Punjab. National dialogue on citrus improvement, production and utilization, held at NRCC, Nagpur, 238.

Thind, S. K. 2021. *The Package of practices for cultivation of fruits*, Punjab Agricultural University, Ludhiana, pp. 1.

MS Received: 27 February 2023
MS Accepted: 24 April 2023