J. Hortl. Sci.
Vol. 7(1):68-74, 2012

Management of melon fly, *Bactrocera cucurbitae* (Coquillett) infesting gherkin:an area-wide control programme adopted in peninsular India

H.M. Praveen, M. Nandeesh, M.R. Chandra Mouli, G.V.G. Rao and S.Vijaysegaran[1]
Global Green Company Limited
#14, 80 feet road,4th Block, Koramangala
Bangalore – 560 034, India
E-mail : chandramouli.mr@globalgreengroup.com

ABSTRACT

An area-wide control (AWC) programme was undertaken for management of melon fly, *Bactrocera cucurbitae* (Coquillet), in 3 km^2 area in Kashapura village of Gauribidanur taluk, Chickaballapura District, Karnataka State in peninsular India from 52nd week of 2007 to 30th week of 2010. Implementation of the AWC programme included field sanitation, male annihilation technique (MAT) through para-pheromone, Cue lure, and bait application technique (BAT). This AWC programme resulted in steady decline of melon fly population in the grid area, and corresponding reduction in per cent fruit fly infested gherkin fruits. In the AWC (grid) area, flies trapped per day (FTD) led to attaining suppression (1 to 0.1 FTD) and eradication levels (<0.1 FTD), which is acceptable to the Indian gherkin-processing industry. Whereas, in the non-grid area, fruit fly populations perpetuated at infestation level (>1 FTD) during majority of weeks under observation.

Key words: *Bactrocera cucurbitae*, gherkin, MAT, BAT, area-wide control (AWC), FTD

INTRODUCTION

Fruit flies are widely distributed around the world. Agarwal and Sueyoshi (2005) reported 243 species of fruit flies from India. Fruit flies lay eggs inside fruits and, upon hatching, the larvae start feeding on pulp, thus making the fruits unfit for human consumption. Fruit flies have a high reproductive potential, with short and overlapping generations. As a result, there can be sudden outbreaks (Bateman, 1972). Availability of both cultivated and wild-fruit hosts round the year enables intenance of their population; hence,fruit flies are a major pest of cultivated fruit crops. The melon fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae), attacks over 81 plant species (Dhillon *et al*, 2005). It is a serious economic pest on cucurbit crops, viz., cucumber (*Cucumis sativus* L.), gherkin (*Cucumis anguria* L.), bitter gourd (*Momordica charantia* L.), ridge gourd (*Luffa acutangula* Roxb.), snake gourd (*Trichosanthes anguina* L.), water-melon (*Citrullus lanatus* L.), muskmelon (*Cucumis melo* L.), pumpkin (*Cucurbita moschata* Duchesne), etc. Extent of loss by melon flies ranges from 30 to 100%, depending on the cucurbit species and season. Fruit infestation by melon fly in bitter gourd has been reported to vary from 41 to 89% (Lall and Sinha, 1959; Narayanan and Batra,1960; Kushwaha *et al*,1973; Gupta and Verma, 1978; Rabindranath and Pillai, 1986). Melon fly has been reported to infest 95% of bitter gourd fruits in Papua New Guinea, and, 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al*, 1997). Singh *et al* (2000) reported 31.27% damage to bitter gourd and 28.55% to watermelon in India. In Nepal, melon fly preferred young and immature summer squash fruits and caused a loss of 9.7% female flowers. Of the total fruits set, more than one-fourth (26%) fruits dropped or were damaged just after set, and 14.04% fruits were damaged during the harvesting stage due to melon fly infestation, yielding only 38.8% fruits of marketable quality in summer squash (Sapkota *et al*, 2010).

Gherkin is a mini-cucumber grown in peninsular India by small and marginal farmers, mainly for export under contract-farming. Like any other cucurbit crop, gherkin is severely affected by tephritid fruit flies such as melon fly, *B. cucurbitae,* and cucurbit fly, *Dacus ciliatus* Loew. Melon fly damages gherkin in three ways: i) oviposition injury by the female on fruits and vegetative parts, ii) larval feeding-

[1]Entomologist Emeritus, Brisbane, Australia,

damage on ovaries and fruit pulp, and iii) decomposition of fly-damaged fruit tissue by invading saprophytic micro-organisms (Viraktamath *et al*, 2004). Fruit fly damage on gherkins reaches 25% during months congenial to the fruit fly (August to October), whereas, level of damage acceptable to the gherkin processing industry is less than 0.3%. Therefore, effective management of fruit flies is very important for successful cultivation and export of gherkins. Management of fruit flies through plot-specific approach by individual growers is ineffective due to poor protocol-compliance, and, availability of other cucurbits as alternate hosts. Therefore, an area-wide control programme need to be implemented as an effective strategy for management of melon fly.

Area-Wide Control (AWC) programme for integrated management of fruit flies comprising field sanitation, male annihilation technique (MAT) and bait application technique (BAT) was tested in peninsular India, where gherkin has been grown for over 22 years and fruit flies are a major threat to this industry.

MATERIAL AND METHODS

The present AWC programme for management of melon fly was implemented in a three km^2 area in Kashapura village of Gauribidanur taluk, Chickaballapura District, Karnataka State in the peninsular India. Gherkin and other traditional crops like maize, ragi, sunflower, groundnut, chilli, tomato and castor were under cultivation in the study area. Other cucurbits like pumpkin, bottle gourd, ridge gourd, bitter gourd and snake gourd were also seen growing in kitchen gardens located in the area. Gherkin, as a main crop, was sown in three seasons a year viz., April – June, July - September and November – February, in the grid area.

Grid area: A three km^2 area in Kashapura village, where the AWC programme was implemented was divided into 50m x 50m grid forming the central zone and surrounding 25m x 25m grid forming the buffer zone (Fig. 1).

Central zone: Area in the grid where Cue lure blocks were installed at every 50m distance.

Buffer zone: Area surrounding the central zone where Cue lure blocks were installed at every 25m distance.

Non-grid area: Area outside the grid area, where AWC programme was not implemented. Gherkin growers in this area followed plot-specific protocol of installation of Cue lure blocks and protein-bait sprays.

Fig 1. Map of Kashapura showing area of AWC program implementation.

Male Annihilation Technique (MAT): Cue lure pheromones laced with Chlorpyriphos-impregnated blocks (Nomate Life Time®, from Agriland Biotech Limited, Gujarat, India) were used for mass-trapping and killing male fruit flies. Cue lure blocks were replaced once every month throughout the year.

Bait Application Technique (BAT): Commercial protein-bait (Prima Protein®, from PUPUK ALM SDN BHD, Malaysia) solution comprising proteins and sugars mixed with Malathion 50EC @ 0.2% was used to attract and kill adult male and female fruit flies under the AWC programme. Strip-application of protein bait was undertaken twice a week on every fifth row of the gherkin plot. Sugar-bait spray consisting of jaggery 10% and Malathion 50EC @ 0.2% was undertaken on the border crop (maize/jowar) grown around gherkin fields on the same day as protein-bait spray application.

Monitoring: To monitor fruit fly population on the gherkin crop, Cue lure and Chlorpyriphos-impregnated blocks suspended in water-bottle traps (Fig. 2) were installed in gherkin fields for both population-estimation and fruit-fly control. For evaluating the effectiveness of MAT and BAT, number of fruit flies trapped was recorded on a weekly basis from the 52nd week of 2007 to 28th week of 2010. Number of fruit flies trapped per day (FTD) was calculated using the following formula:

$$\text{Fruit flies trapped per day (FTD)} = \frac{\text{Number of fruit flies caught in the trap}}{\text{Number of traps X Number of days}}$$

Fig 2. Water bottle trap containing Cue lure block impregnated with insecticide

Fig 3. Fruit-juice bait trap

Effectiveness of the AWC programme was rated based on the following FTD index

Area index for Fruit flies	FTD range
Infestation	>1.0
Suppression	1.0 to 0.1
Eradication	<0.1
Exclusion	0

Regression function analysis: To analyze influence of FTD in the AWC programme, represented by per cent fruit fly infested gherkin fruits, regression function analysis was carried out as shown below:

$Y = b_0 + b_1 X + b_2 D_i$

Y = Per cent fruit damage

X = FTD

D_i = Dummy variable, D_i = 1 for the grid and D_i = 0 for the non-grid

Sanitation: Field-sanitation practices like removal of neglected/abandoned gherkin crops and alternate hosts, and destruction of fruits rejected during the buying activity, were followed uniformly in the entire grid.

Public awareness: Farmers' meetings in schools and public places were conducted in the grid area. During the meetings, pamphlets were distributed and banners displayed on fruit-fly management to create public awareness of the AWC programme.

Per cent fruit-fly infested gherkin fruits: Fruits from the grid and non-grid area were examined daily on arrival at processing units during the three seasons, and percentage of fruit-fly infestation was calculated on weight basis.

Fruit fly hotspot identification and suppression: In the AWC programme, to identify fruit fly hotspots within the grid, traps were continuously monitored. Location where more than four flies were trapped per week in a monitoring trap were considered as hotspots. These hotspots frequently turned out to be abandoned gherkin plots or spots with alternate hosts for fruit flies in the grid. In these hotspots, fruit flies were suppressed by installing water-bottle traps (Fig. 3) containing 250ml of fruit-juice bait [Fresh watermelon juice 500ml+sodium benzoate 10g+ammonium carbonate 0.8g+insecticide (Malathion 50 EC) 3ml and water 486.2ml].

RESULTS AND DISCUSSION

Fruit flies trapped per day (FTD)

The AWC programme was initiated in the 52nd week of 2007 in Kashapura (Fig. 4). In the grid area, 1.21 FTD was recorded before implementation of AWC and, subsequently, it reduced to 0.07 FTD during the 4th week of 2008. Thereafter, FTD was less than 0.50,except in the 5th week of 2010 and 28th week of 2010, with 0.72 and 0.84 FTD, respectively.

During the corresponding period in the non-grid area, higher number of fruit flies were trapped with highest FTD of 3.55 in the 45th week of 2009, followed by 3.25 in the 28th week of 2009, 2.83 in the 5th week of 2010 and 2.37 in the 29th week of 2008 (Annexure I).

Per cent fruit-fly infested gherkin fruits

In the grid area, highest per cent of (1.94) fruit-fly infested gherkin fruits were recorded in the 17th week of 2009, followed by 1.42 (15th week of 2009), 1.18 (30th week of 2009), 0.91 (1st week of 2008) and 0.83 (7th week of 2009). During the rest of the period of AWC programme, less than 0.7 % (Fig. 6) infested gherkin fruits were recorded.

Annexure 1. No. of fruit flies (*Bactrocera cucurbitae*) trapped per day (FTD) in the grid and the non-grid areas.

Month	Calendar year week	No. of fruit flies trapped per day (FTD) from December 2007 to July 2010					
		2008		2009		2010	
		Grid	Non-grid	Grid	Non-grid	Grid	Non-grid
Dec-2007	52	1.21	-		-		
January	1	0.90	-	0.03	-	0.36	1.83
	2	0.38	-	0.03	-	0.38	1.17
	3	0.22	-	0.01	-	0.36	2.00
	4	0.07	0.33	0.02	-	0.24	1.67
	5	0.08	0.59	0.14	0.29	0.72	2.83
February	6	0.09	-	0.03	0.07	0.36	1.33
	7	0.15	0.37	0.01	0.19	0.48	1.00
	8	0.09	-	0.01	0.14	0.38	0.88
	9	0.42	-	0.01	0.14	0.20	0.63
March	10	0.09	-	0.01	0.29	0.08	0.63
	11	-	-	0.01	1.00	0.10	0.38
	12	-	-	0.02	0.86	0.10	0.75
	13	-	-	0.03	1.36	0.06	0.50
April	14	-	-	0.05	0.93	0.06	0.50
	15	-	-	0.02	-	0.04	0.25
	16	-	-	0.02	-	0.02	0.25
	17	-	-	0.01	-	0.00	0.00
May	18	-	-	0.01	-	0.02	0.13
	19	-	-	0.01	-	0.02	0.13
	20	-	-	0.00	-	0.02	0.50
	21	-	-	-	-	0.04	0.50
	22	0.00	-	-	-	0.02	0.38
June	23	0.00	-	-	-	0.06	0.50
	24	0.01	-	0.01	-	0.04	0.50
	25	0.01	0.96	0.01	-	0.10	0.75
	26	0.00	0.66	0.01	-	0.16	0.63
July	27	0.01	0.25	0.01	-	0.22	1.13
	28	0.04	1.51	0.04	0.05	0.84	3.25
	29	0.04	2.37	0.11	0.02	0.46	2.00
	30	0.10	1.10	0.07	0.02	0.42	1.25
	31	0.02	0.90	0.03	0.29	-	-
August	32	0.07	-	0.09	0.26	-	-
	33	0.14	-	0.15	0.17	-	-
	34	0.02	-	0.20	0.43	-	-
	35	0.03	-	0.09	0.36	-	-
September	36	0.03	-	0.07	0.26	-	-
	37	0.00	-	0.09	0.21	-	-
	38	0.05	-	0.06	0.31	-	-
	39	0.34	-	0.08	0.19	-	-
October	40	0.10	0.66	0.08	0.29	-	-
	41	0.24	0.86	0.03	0.24	-	-
	42	0.26	0.64	0.10	0.67	-	-
	43	0.27	0.69	0.23	0.95	-	-
	44	0.15	0.45	0.15	1.81	-	-
November	45	0.10	0.16	0.07	3.55	-	-
	46	0.13	0.24	0.04	1.29	-	-
	47	0.19	0.38	0.15	1.69	-	-
	48	0.10	0.40	0.10	1.52	-	-
December	49	0.09	0.45	0.07	0.69	-	-
	50	0.05	0.55	0.04	0.64	-	-
	51	0.00	0.36	0.01	0.48	-	-
	52	0.05	0.33	0.02	0.43	-	-

Annexure 2. Per cent fruit fly infested gherkin fruits

Date of observation	Grid	Non-grid	Date of observation	Grid	Non-grid		Date of observation	Grid	Non-grid
23-Nov-08	0.40	-	10-Mar-09	0.00	-	-	26-Oct-09	0.00	3.46
24-Nov-08	0.31	-	11-Mar-09	0.00	-	-	27-Oct-09	0.00	5.34
25-Nov-08	0.79	-	08-Jul-09	0.00	1.20	-	28-Oct-09	0.86	1.80
26-Nov-08	0.43	-	10-Jul-09	0.42	1.02	-	29-Oct-09	0.84	3.08
27-Nov-08	0.35	-	11-Jul-09	0.44		-	30-Oct-09	1.18	1.06
29-Nov-08	0.62	-	13-Jul-09	0.33	1.24	-	31-Oct-09	0.00	4.52
01-Dec-08	0.91	-	14-Jul-09	0.28	0.98	-	02-Nov-09	0.00	3.66
03-Dec-08	0.40	-	15-Jul-09	0.33	1.32	-	03-Nov-09	0.44	3.14
31-Jan-09	0.00	-	16-Jul-09	0.21	1.25	-	04-Nov-09	0.34	3.66
01-Feb-09	0.10	-	17-Jul-09	0.41	0.40	-	07-Nov-09	0.50	1.44
03-Feb-09	0.37	-	19-Jul-09	0.41		-	10-Nov-09	0.61	1.11
05-Feb-09	0.33	-	20-Jul-09	0.18	0.16	-	01-Jul-10	0.00	0.33
09-Feb-09	0.15	-	21-Jul-09	0.21	0.22	-	02-Jul-10	0.10	0.38
10-Feb-09	0.31	-	22-Jul-09	0.18	0.42	-	03-Jul-10	0.40	0.39
11-Feb-09	0.00	-	23-Jul-09	0.12	1.22	-	04-Jul-10	0.47	0.53
12-Feb-09	0.38	-	25-Jul-09	0.21	0.84	-	05-Jul-10	0.09	0.26
13-Feb-09	0.00	-	26-Jul-09	0.28	0.22	-	08-Jul-10	0.33	0.53
14-Feb-09	0.10	-	27-Jul-09	0.22	0.40	-	11-Jul-10	0.19	0.66
15-Feb-09	0.13	-	28-Jul-09	0.00	1.20	-	16-Jul-10	0.22	0.69
17-Feb-09	0.22	-	29-Jul-09	0.59	1.30	-	17-Jul-10	0.38	0.33
20-Feb-09	0.00	-	30-Jul-09	0.42	0.96	-	19-Jul-10	0.49	0.86
21-Feb-09	0.00	-	13-Oct-09	0.40	1.16	-	20-Jul-10	0.11	0.30
24-Feb-09	0.00	-	14-Oct-09	0.48	1.46	-	21-Jul-10	0.22	0.32
28-Feb-09	0.07	-	15-Oct-09	1.42	3.38	-	22-Jul-10	0.22	0.33
01-Mar-09	0.08	-	16-Oct-09	0.54	0.72	-	24-Jul-10	0.27	0.28
03-Mar-09	0.15	-	17-Oct-09	1.94	5.64	-	25-Jul-10	0.13	1.20
04-Mar-09	0.00	-	18-Oct-09	0.00	4.38	-	30-Jul-10	0.16	0.93
05-Mar-09	0.00	-	19-Oct-09	0.20	3.22	-	31-Jul-10	0.21	0.33
06-Mar-09	0.23	-	20-Oct-09	0.66		-	-	-	-
07-Mar-09	0.83	-	23-Oct-09	0.00	2.22	-	-	-	-
08-Mar-09	0.00	-	24-Oct-09	0.44	3.02	-	-	-	-
09-Mar-09	0.19		25-Oct-09	0.26	5.30	-	-	-	-

During the corresponding period in the non-grid area, high percentage of 5.64, 5.34, 5.30, 4.52, 4.38, 3.66, 3.66 infested gherkin fruits were recorded from 42nd week to 45th week of 2009. However, during the other weeks of observation, per cent fruit-fly infested gherkin fruits was higher compared to that in the grid area.

Suppression of fruit flies in the hotspot: In the grid area, fruit fly hotspots were identified based on trap catches (FTD). Before installation of fruit juice traps, hotspots recorded a maximum of 16 and 9 fruit flies during Jan.-Feb. 2009 (4 hotspots) and Oct. 2009 (5 hotspots), respectively. Three weeks after installing fruit-juice bait traps, number of fruit flies trapped dropped down to zero.

Cumulative frequency of melon fly

Cumulative frequency (Fig. 5) of fruit flies trapped per day recorded from the 28th week of 2009 to the 30th week of 2010 for grid and non-grid areas showed that the curve for the grid area was low and stabilized, whereas in the non-grid area, it progressively increased. During the above period, cumulative FTD in the grid area was 21.51 compared to 148.13 in the non-grid area. This shows a continuous reduction in fruit fly population in the grid area with implementation of AWC programme.

Relationship between per cent fruit-fly infested gherkin and FTD in the grid area: A correlation analysis was carried out between fruit-fly infested gherkin fruits in the factory and FTD for the grid area. The resultant correlation coefficient was 0.0218, which suggests a positive correlation between fruit-fly infestation and FTD.

Multi-linear regression analysis was carried out to examine the influence of number of fruit flies trapped per day and presence or absence of AWC program on extent of fruit damage (Table 1).

Both the grid and non-grid variables had significant

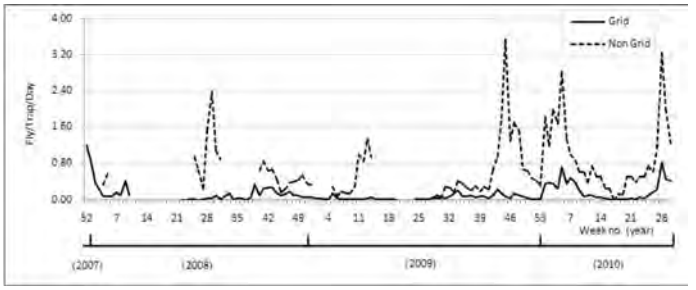

Fig 4. Fruit flies (*Bactrocera cucurbitae*) trapped per day (FTD) of in the grid and non-grid areas

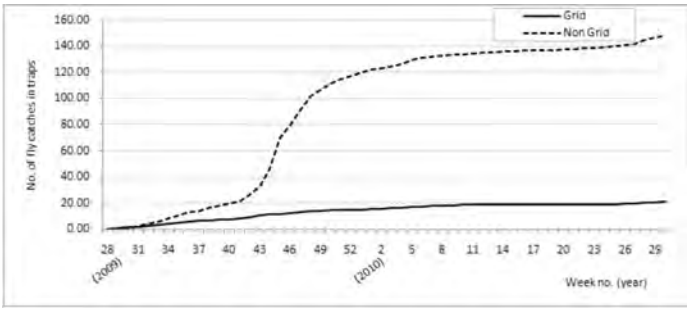

Fig 5. Cumulative frequency of *Bactrocera cucurbitae* FTD in the grid and non-grid areas

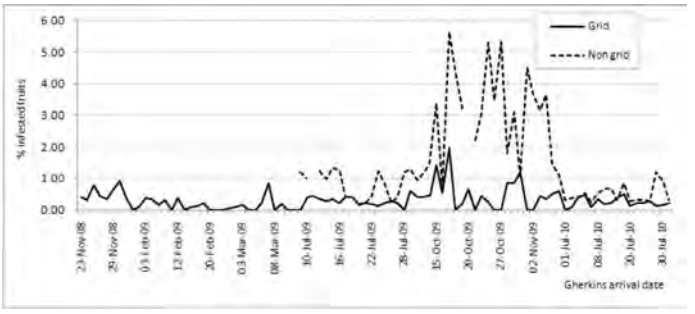

Fig 6. Per cent fruit fly (*Bactrocera cucurbitae*) infested gherkin fruits in the grid and the non-grid areas.

influence on percentage of fruit infestation. With the number of fruit flies trapped per day decreasing by one, per cent fruit-fly infestation also came down.

Implementation of the AWC programme has been effective in maintaining stabilized, lower fruit-fly population (FTD) in the grid area compared to non-grid area. In the grid area, fruit fly populations were at suppression (1.0 to 0.1 FTD) and eradication level (<0.1 FTD), which is acceptable to the Indian gherkin-processing industry. Whereas, in the non-grid area, fruit fly populations were seen at infestation level (>1 FTD) during most of the weeks under observation. These results are in conformity with area-wide control of fruit flies in Mauritius (Sookar *et al*, 2006) where the population of *Ceratitis capitata* and *Ceratitis rosa* decreased significantly with simultaneous decrease in infestation levels in peach fruit orchard.

Table 1. Regression analysis for estimating relationship between the grid and non-grid area

Variable	Regression coefficient	'*t*' value	'*p*' value
Intercept	1.19	5.76	0.0000007**
No. of ruit fly trapped per day (FTD)	0.32	2.45	0.015855*
Dummy variable for Grid = 1, and Non-grid = 0	-0.90	-3.85	0.0002**

R^2 = 0.2834, or 28.34%

Implementation of AWC programme resulted in steady decline in *B. cucurbitae* population in the grid area and a corresponding reduction in per cent fruit-fly infested gherkin fruits.

Correlation analysis for the grid area leads to the conclusion that there is a positive relationship between per cent fruit-fly infestation and FTD. This positive correlation means that as FTD decreases, correspondingly, per cent fruit-fly infestation also decreases. However, the relationship was statistically not found very strong.

In AWC programme, there was a decrease in per cent infestation of damaged fruits as per coefficient for dummy variable. R^2, coefficient of multiple determination, explained about 28.34% variation in per cent infested fruits.

Presently in India, gherkin cultivation is under the contract farming system involving small and marginal farmers in rural areas. However, implementation of the AWC program by individual farmers is not economically feasible. Therefore, a collaborative community-approach involving the State and Union Governments and Research organizations is the only way out for management of fruit flies through the AWC programme.

ACKNOWLEDGEMENT

We would like to thank Mr. Vineet Chhabra, Managing Director and Group CEO, Global Green Company Limited for permission to publish this work. The authors are also thankful to Dr. C.A. Viraktamath, Dr. B. Mallik, Mr. B.V. Ramakrishna, Department of Entomology, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore, India for reviewing the manuscript, for statistical analysis and their valuable inputs.

REFERENCES

Agarwal, M.L. and Sueyoshi, M. 2005. Catalogue of Indian fruit flies (Diptera: Tephritidae). *Oriental Insects*, **39**:371-433

Bateman, M.A. 1972. The ecology of fruit flies. *Ann. Rev. Ent.*, **17**:493-518

Dhillon, M.K., Ram Singh, Naresh, J.S. and Sharma, H.C. 2005. The melon fruit fly, *Bactrocera cucurbitae*: A review of its biology and management. *J. Insect Sci.*, **5**:16p

Gupta, J.N. and Verma, A.N. 1978. Screening of different cucurbit crops for the attack of the melon fruit fly, *Dacus cucurbitae* Coq. (Diptera: Tephritidae). *Haryana J. Hortl. Sci.,* **7**:78-82

Hollingsworth R., Vagalo M. and Tsatsia, F. 1997. Biology of melon fly, with special reference to the Solomon Islands. **In:** Allwood, A.J. and Drew, R.A.I. (editors.) Management of fruit flies in the Pacific. *Proc. Australian Country Indus. Agri. Res.,* **76**:140-144

Kushwaha, K.S., Pareek, B.L. and Noor, A. 1973. Fruit fly damage in cucurbits at Udaipur. *Udaipur Univ. Res J.*, **11**:22-23

Lall, B.S. and Sinha, S.N. 1959. On the biology of the melon fly, *Dacus cucurbitae* (Coq.) (Diptera: Tephritidae). *Sci. & Cul.*, **25**:159-161

Narayanan, E.S. and Batra, H.N. 1960. Fruit flies and their control. Indian Council of Agricultural Research, New Delhi, India, 68 pp

Rabindranath, K. and Pillai, K.S. 1986. Control of fruit fly of bitter gourd using synthetic pyrethroids. *Entomon*, **11**:269-272

Sapkota, R., Dahal, K.C. and Thapa, R.B. 2010. Damage assessment and management of cucurbit fruit flies in spring-summer squash. *J. Entom. and Nemat*, **2**:7-12

Singh, S.V., Mishra, A., Bisan, R.S., Malik, Y.P. and Mishra, A. 2000. Host preference of red pumpkin beetle, *Aulacophora foveicollis*, and melon fruit fly, *Dacus cucurbitae*. *Ind. J. Ent.,* **62**:242-246

Sookar, P., Permalloo, S., Gungah, B., Alleck, M., Seewooruthun, S.I. and Soonnoo, A.R. 2006. An area-wide control of fruit flies in Mauritius. Fruit flies of Economic importance: From basic to applied knowledge. *Proc. 7th Internatl. sym. Fruit flies Econ. importance*, Brazil, 261-269

Viraktamath, C.A., Mallik, B., Chandrashekar, S.C., Ramakrishna, B.V. and Praveen, H.M. 2003. Insect Pests and Diseases on Gherkins and their Management. University of Agricultural Sciences, Bangalore, India 65pp

(MS Received 23 December 2010 Revised 24 January 2012)