EVALUATION OF BAIT APPLICATION TECHNIQUE FOR THE MANAGEMENT OF FRUIT FLIES INFESTING CUCURBITS

VIDYA, L.

Thesis submitted in partial fulfilment of the requirement
for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2005

Department of Agricultural Entomology
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

DECLARATION

I hereby declare that this thesis entitled "**Evaluation of Bait Application Technique for the management of fruit flies infesting cucurbits**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
26-12-2005

VIDYA, L.
(2003-11-06)

CERTIFICATE

Certified that this thesis entitled "**Evaluation of Bait Application Technique for the management of fruit flies infesting cucurbits**" is a record of research work done independently by Ms. Vidya. L (2003-11-06) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani,
26-12-2005

Dr. T.JIJI
(Chairperson, Advisory Committee)
Assistant Professor,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram.

Approved by

Chairperson :

Dr. T. JIJI
Assistant Professor,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

26/12/2005

Members :

Dr. T. NALINAKUMARI
Associate Professor and Head,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

26.12.2005

Dr. THOMAS BIJU MATHEW
Associate Professor,
Department of Agricultural Entomology,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

26/12

Dr. M. SUHARBAN
Professor of Plant Pathology,
Instructional Farm,
College of Agriculture, Vellayani,
Thiruvananthapuram-695522.

26/12

External Examiner :

26/12/05
Dr. G. Madhavan Nair

ACKNOWLEDGEMENT

With utmost reverence and deep sense of admiration, I express my heartfelt gratitude and indebtedness to:

Dr. Jiji, T., Assistant Professor, Department of Agricultural Entomology and Chairperson of Advisory Committee for suggesting the research problem, helping to plan the experiments, valuable guidance, constructive criticism and constant support throughout the research work.

Dr. T. Nalinakumari, Associate Professor and Head, Department of Agricultural Entomology for her timely advices, masterly guidance and overwhelming support extended at all stages of the work.

Dr. Thomas Biju Mathew, Associate Professor, Department of Agricultural Entomology for his valuable suggestions, critical scrutiny of the manuscript and friendly approach throughout the course of research.

Dr. M. Suharban, Professor of Plant Pathology, Instructional Farm for her timely suggestions, keen interest, supervision and help rendered in the field experiment.

Dr. K.D. Prathapan, Assistant Professor, Department of Agricultural Entomology for extending all possible help during the identification of insect specimens.

Dr. Anitha. N, Assistant Professor, Department of Agricultural Entomology for her valuable suggestions and help rendered during the thesis work.

Dr. Hebsybai, Dr. K. Sudharma, Dr. C. Nandakumar, Dr. M.S. Sheela, Dr. Naseema Beevi, Dr. J. Arthur Jacob, Dr. S. Devanesan, Dr. Premila, and Dr. M.H. Faizal for their encouragement throughout the study.

Dr. Vijayaraghavakumar, Associate Professor, Department of Agricultural Statistics and Shri. Ajithkumar, Programmer for the help rendered in connection with the statistical interpretation of experimental data.

The labourers, College of Agriculture, Vellayani for their wholehearted co-operation and help.

Kerala Agricultural University for awarding Junior Research Fellowship for the PG programme.

Shri. Jayakumar, Thamilvel and Priya chechi for taking nice photographs for the thesis.

My classmates Sahi, Asha, Manu and Shaiju for their generous assistance and moral support extended throughout the study. Praveena chechi, Ambily chechi, Nisha chechi, Lekha chechi, Rani chechi, Smitha chechi, Sheena chechi, and Simi chechi for offering me help whenever required. My junior friends for their loving involvement during various stages of work. All my friends for their support and company.

My husband, our parents and sister for their glorious love, moral support, encouragement and prayers which enabled me to pursue this endeavour successfully.

Above all, I bow my head before God Almighty without whose blessings the thesis would not have materialized.

VIDYA.L
(2003 – 11 – 06)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

%	Per cent
@	At the rate of
^{0}C	Degree Celsius
CD	Critical difference
cm	Centimetre(s)
DAS	Days After Sowing
WAS	Weeks After Sowing
EC	Emulsifiable Concentrate
et al.	And others
Fig.	Figure
G	Granule
g	Gram
h	Hour
kg	Kilogram
l	Litre
m	Metre
m^2	Metre square
ml	Millilitre
spp.	Species
viz.	Namely
WP	Wettable Powder
SP	Soluble Powder
POP	Package of Practice

Introduction

1. INTRODUCTION

Vegetables are important components of human diet and rich sources of minerals, vitamins, fibre and other essential nutrients. In Kerala the daily per capita consumption level of vegetables is 125g per day, which is much below the national average (PPM Cell, 1996). This is mainly due to the low production of vegetables in the state. Owing to the low vegetable production, Kerala has become a consumer state. Hence, there is an urgent need for improving its vegetable production by concentrating on increase in productivity.

Cucurbits are extensively cultivated in Kerala. One of the most important constraints in cucurbit cultivation is pest incidence. Melon fly was considered as the most serious pest under Kerala conditions (Dale, 1965). They are active throughout the year in southern regions of India due to favourable climatic conditions (Kapoor, 1993).

In cucurbits, fruit flies can cause a crop loss of 50 per cent (Narayanan and Batra, 1960). Stonehouse *et al.* (1998) reported that in India fruit flies caused a yield loss of 10 to 40 per cent and an estimated annual loss of Rs.2600 crores.

For managing fruit flies farmers resort to chemical pesticides, often in an indiscriminate and unjudicious manner (Rahiman *et al.*, 1986). Santhoshkumar (1997) obtained residues of methyl parathion, monocrotophos and quinalphos in all the seventy two market samples of vegetables analysed. All these findings necessitates an alternate method for chemical control, for the management of fruit flies.

Bait Application Technique is considered as an ecofriendly fruit fly management measure. Although a few food baits are currently in use there can be more promising baits, the use of which has to be standardised and popularised among farmers. So also there are many types of containers

used by farmers for dispensing the baits and trapping the fruit flies. Documentation of farmers' practices, investigating the incidence and diversity of fruit flies infesting cucurbits and standardization of fruit fly traps will help to chalk out suitable pest management strategies. The present investigation was therefore undertaken :-

1. to document fruit fly incidence in cucurbits and farmers' practices in cucurbit cultivation,
2. to screen potential food baits for trapping fruit flies in field,
3. to standardize efficient containers for trapping them in field and
4. to optimize the spacing of traps in field.

Review of Literature

2. REVIEW OF LITERATURE

The present study aims at the evaluation of Bait Application Technique for the management of fruit flies infesting cucurbits. The relevant works pertaining to incidence and diversity of fruit flies and their management giving special emphasis to food baits are reviewed here.

2.1. INCIDENCE AND DIVERSITY OF FRUIT FLIES IN THE FIELD

2.1.1. Occurrence and distribution

Fruit flies were reported from various parts of India by different authors. Fruit flies were considered as most serious pests of cucurbits in Kerala (Dale, 1965). Gupta *et al.* (1992) reported fruit flies as major pests of bittergourd all over India. Fruit flies were found to infest cucumber in Himachal Pradesh (Gupta *et al.*, 1992), in Bangladesh (Nasiruddin and Karim, 1992) and in Assam (Borah, 1996).

Patel (1994) and Patel and Patel (1996) reported fruit fly as pest of littlegourd. Fruit flies were reported as pests of melon in Rajasthan (Pareek and Kavadia, 1995). Borah and Dutta (1997) reported that fruit flies were major pests of snakegourd all over India.

Narayanan and Batra (1960) reported that fruit fly incidence occurred mainly during July- September and monsoon crop was considered as most vulnerable. The incidence and distribution of fruit flies throughout South Asia was extensively studied (Kapoor *et al.*, 1976; Agarwal and Kapoor, 1985, 1988; Kapoor, 1989). Shukla and Prasad (1985) found that the key determinants of fly abundance were host availability, median temperature and relative humidity. Trap catches indicated the fluctuations of fruit fly population seasonally (Gupta *et al.*, 1992; Murthy and Reghupathy, 1992;

Patel, 1994; Kumar *et al.*, 1997; Verghese, 1998; Agarwal and Kumar, 1999). Temperature and diet were found to have effect on life cycle of fruit flies (Murthy and Reghupathy, 1992; Sangwan and Lakra, 1992; Dashad *et al.*, 1999). It was found that there was high correlation between temperature and abundance of flies (Patel and Patel, 1996,1998; Agarwal and Kumar, 1999). From the study of factors affecting fruit fly population ecological models were developed which helped in accurate prediction of fruit fly incidence upto 74 per cent and for adoption of proper control measures (Verghese, 1998).

2.1.2. Nature and extent of damage

Narayanan (1953) reported that adult female fruit flies preferred tender fruits to lay eggs and the emerging maggots fed on flowers and sometimes even on stem of cucurbit vines forming characteristic galls. The adult female flies were found to lay eggs on the fruit just beneath the fruit rind using ovipositor and the emerging maggots fed on the internal content of the fruit, which resulted in fruit decay and ultimate loss of fruit (Dale, 1965; Nair, 1999). Sarode *et al.* (1981) reported that the damage of fruit flies on cucurbits made the fruits unfit for human consumption. Bose and Mehrotra (1986) found that the insertion of ovipositor caused wounds on the fruits in the form of punctures and a fluid exuded out. They also found that the fluid later dried and appeared as resinous deposit.

B. cucurbitae and *Bactrocera dorsalis* (Hendel) were major fruit fly species with 125 and 173 hosts respectively (Kapoor, 1993). According to Patel (1994) *Dacus ciliatus* Loew. was found infesting coccinia faster than other cucurbits. Gupta and Verma (1995) found that melon fly had lower survival and slower development on spongegourd than on bittergourd and cucumber. The fruit flies were found to cause very high losses in farm level, which affected the traders, retailers and exporters and percentage losses due

to fruit flies was estimated by Stonehouse *et al.* (1998). They found that fruit flies caused 40 per cent loss in melon, 47 per cent loss in bittergourd, 35 per cent loss in cucumber, 40 per cent loss in littlegourd and 40 per cent loss in snakegourd. They also reported that in India fruit flies cause a yield loss of 10-40per cent and an annual loss of Rs.2600 crores. According to Sivakumar (2001) the damage ranged from 12.1 to 15.7per cent in treated plots and 27.0 to 63 per cent in farmer's field. Pareek and Bhargava (2003) found that *Bactrocera cucurbitae* (Coquillett) caused an yield loss of 64- 90 per cent in long melon, 57 to 85 per cent in round gourd, 59 to 84 per cent in bittergourd and 63 – 88 per cent loss in musk melon during Ziad (March-June) in Rajasthan.

Important hosts of fruit flies and records of losses caused by them in India as reported by various authors are as follows.

Sl.No.	Hosts	Loss(per cent)	Source
1	Jujube	30-35	Farod (1996); Sharma *et al.* (1998); Arora *et al.* (1999) Dashad *et al.* (1999)
2	Guava	30-40	Mukhmoor and Singh (1998); Jalaluddin *et al.* (1999)
3	Mango	30-50	Kapoor (1972), Shukla *et al* (1984); Kumar *et al.* (1997)
4	Moringa	20-25	Murthy and Regupathy (1992)
5	Phalsa	50-60	Mann (1994)
6	Melon	50-75	Pareek and Kavadia (1995)
7	Bittergourd	40-60	Kapoor (1971), Gupta *et al.* (1992)
8	Bottlegourd	40-80	Gupta *et al.* (1992)

9	Cucumber	35-50	Gupta *et al.* (1992); Borah (1996)
10	Littlegourd	38-45	Patel (1994); Patel and Patel (1996)
11	Ridgegourd	0	Kapoor (1993)
12	Snakegourd	40-60	Borah and Dutta (1997)
13	Spongegourd	40-50	Gupta *et al.* (1992)

2.2. BIOLOGY OF FRUIT FLIES

Gupta and Verma (1993) studied the biology of *Bactrocera tau* (Walker) in bittergourd and recorded an egg period of 1-2 days, larval period of 3-4 days, pupal period of 5-6 days and an adult longevity of 30.1 days for female and 25.0 days for male. The number of flies emerged per fruit was 191.1. The biology of *B. cucurbitae* was reported by Bhagat and Koul (1999). They recorded an egg period of 1.00days, larval period of 4.96 days and pupal period of 6.94 days. The biology of *Bactrocera zonata* (Saunders) in banana was recorded by Darz and Hashem (2003). They found larval period of 10.70 days and pupal period of 10.03 days and the average number of eggs per female was found to be 372.33.

2.3. NATURAL ENEMIES

Fullaway (1915), Clausen (1950), Nishida and Bess (1957) and Nair (1995) found that *Opius fletcheri* Silv. was a larval pupal parasitoid of fruit flies. Braconid parasitoids *Diachasmimorpha longicaudata* (Ashmead) and *Opius fletcheri* were reported from *B. dorsalis* and *B.cucurbitae* respectively (Ibrahim *et al.*, 1994; Duan and Messing, 1997). *Opius compensatus* Silv., *Opius incisus* Silv. and *Spalangia philippinensis* Full. were reported as

parasites of fruit fly by Nair (1999). *Psyttalia cosyrae* (Wilkinson) (Hymenoptera: Braconidae) was reported as larval – pupal parasitoid of *Ceratitis cosyra* (Walker) (Mohamed *et al.*, 2003).

Rhizoctonia solani Kuhn was reported as toxic to *B. cucurbitae* (Sinha, 1997). *R.solani* was found to affect the oviposition and development of *B. cucurbitae*. (Sinha and Saxena, 1999). *Aspergillus candidus* Link was found to be pathogenic to *B. dorsalis* (Jiji *et al.*, 2003a).

2.4. MANAGEMENT

2.4.1. Food bait traps

Many authors reported that bait trap comprising of attractant and an insecticide was found to reduce the fruit fly population considerably. Studies in Taiwan showed that methyl eugenol and cuelure could be used to trap *B. cucurbitae* in cucurbits (Fang and Chang, 1984). Liu and Chang (1995) found that the fruit flies were attracted to bait containing molasses and tryptone(9:1) and the adult attraction also increased with the use of yellow sticky paper. Liu *et al.* (1997) used polythene bottles filled with guava juice, durian protein extract and cuelure solution as attractant for trapping *B. cucurbitae*. Although meat baits were found to be effective they were unacceptable for a large population of vegetarian farmers and consumers (Stonehouse *et al.*, 1998). Sewoosunkur *et al.* (2000) found that fruit fly catches were greater when protein autolysate was prepared with high concentration of papain (2.0 or 4.0g / l). Liu and Hwang (2000) found that 50 per cent molasses mixed with ethyl acetate and ethyl butyrate in the ratio of 5 : 5 had higher attraction of 54.7per cent to the adult flies. Vargas *et al.* (2000) found that methyl eugenol and cuelure were highly attractive kairomones to oriental fruit fly (*B. dorsalis*) and melon fly (*B. cucurbitae*) respectively. In attracting and killing *B. cucurbitae* beef meat broth was

found to have 68.7 per cent effectiveness when compared to commercial protein hydrolysate (Stonehouse *et al.*, 2002).

Maximum catch of both sexes of *B. cucurbitae* was obtained when a bait containing fermented palm juice (one part), saturated sugar solution (one part) and malathion @50WP 5.0g/100ml was used (Lall and Singh, 1960). The infestation of fruit fly *B. dorsalis* in mango decreased from 33.7per cent to 0.6per cent when a bait containing methyl eugenol 1.0per cent and carbaryl 0.1per cent was used (Lakshmanan *et al.*, 1973). Shah and Patel (1976) observed that leaves of *Ocimum sanctum* L. attracted male flies of *Dacus* spp. in mango and chikku. Gupta and Verma (1982) reported that protein hydrolysate could be used to attract fruit fly adults and fruit sucking moths. Agarwal *et al.* (1987) found that spraying the plants with 500g molasses and 50g malathion in 50 litre water at seven days interval resulted in good control of fruit flies. Nasiruddin and Karim (1992) recommended the setting up of bait trap of 0.5g dipterex 80SP (trichlorfon) with 100g sweetgourd mash to control *B. cucurbitae* attacking snakegourd. Similar observations were made by Chowdhary *et al.* (1993). They found that average fruit flies trapped per day ranged from 2.36 to 4.57. Srinivasan (1993) found 1per cent yeast protein and 1per cent sugar as attractant materials for fruit flies. Benzyl acetate attracted *B. dorsalis* and *B. cucurbitae* (Kapoor, 1993). Reghupathy *et al.* (1997) recommended poison baiting containing saturated sugar solution 5.0ml and malathion 50 EC 5.0 ml + 100ml fermented palm juice for controlling fruit flies. They also reported that setting up of trap containing 5.0 g wet fish meal in polythene bags (20cm x 15cm) with six holes and a drop of dichlorvos (0.1ml) in cotton plug inside the bag was found to be effective in controlling fruit flies. Brewer's yeast which is available as acetone dried yeast was found as an attractant for fruit flies (Singh, 1997). He also found that three fourth ounce each of yeast and brown sugar in one gallon of water

could be used as bait material for fruit flies. Sood and Nath (1998) found that jaggery trap showed higher attraction to fruit flies when compared to sugar traps. The attractant bait mixture containing boric acid – borax (3:1) as toxicant, protein hydrolysate (4 per cent) as attractant in water, when fed to adult of fruit fly caused 40.00 - 98.30 per cent mortality in 24 h of exposure with different concentrations (1-12 per cent) of the toxicant (Susnandita and Gupta, 2001).

Sprinkling of a coarse spray with liquid bait containing 1.0 per cent yeast protein and 0.1per cent malathion was found to be effective for the management of melon fly (Dale, 1965). Fruit traps using palayankodan or poovan with one percent honey were effective in trapping both sexes of fruit fly in bittergourd (Jalaja, 1989). Pillai *et al.* (1991) recommended the use of bait traps using Palayankodan fruits sprinkled with carbofuran granules @ 1.0 g /piece for better control of fruit fly, *B. cucurbitae* . They also found that plantain fruit was superior to jaggery, honey and molasses and that dishes hung from pandals could be used as containers for carrying the bait materials. Reghunath and Indira (1993) found that *B. cucurbitae* and *B. dorsalis* could be attracted to a trap containing 20g crushed *O. sanctum* leaves, 0.5 g citric acid and 0.5g carbofuran in100ml water placed in coconut shell. No lure was known against *Dacus ciliatus* (Patel and Patel, 1998). A trap for *Bactrocera* spp. was developed using soaked wooden blocks with methyl eugenol (Verghese 1998). Snakegourd infestation by fruit fly (*B. cucurbitae*) could be effectively controlled by the use of banana traps coupled with the removal and destruction of infested fruits (Nair, 1999). Nandakumar (1999) advocated setting up of coloured coconut shell trap containing carbofuran smeared banana fruit (Palayankodan) alternated with carbofuran poisoned ocimum jaggery trap at 2.0m spacing for the management of fruit flies in bittergourd. Sarada *et al.* (2001) found that more number of flies were attracted to white

and yellow traps followed by green, orange, red and blue respectively. Banana traps consisting of Palayankodan fruit pieces and carbofuran 3G was found to be the best in catching fruit flies and the mean number of flies caught ranged from 4.7 to 9.3 (Sivakumar, 2001). Verghese and Jayaynthi (2001) devised a convenient polythene sachet for trapping fruit flies. Fruit flies could be effectively controlled by the banana fruit trap kept at 2m spacing after a border row and replenishing the bait after seven days (KAU, 2002). In an experiment conducted in College of Agriculture, Vellayani, Jiji *et al.* (2003b) found that food bait containing Robusta + jaggery + carbofuran recorded maximum male count and Red banana + boiled Jaggery + carbofuran had highest female count. They also found that combinations of fruit pulp with boiled jaggery was very effective and it increased the keeping quality of food baits.

2.4.2. Management practices adopted by farmers

The related works on the different practices adopted by farmers for effective management of fruit flies are quoted here.

2.4.2.1. Cultural Control

Narayanan (1953) reported that ploughing of the field would destroy the fruit fly pupae, which was found in soil. Wesley (1956) observed that sowing of early or late varieties of cucurbitaceous vegetables and raking up of soil under the infested plants during winter months would destroy hibernating pupae. Khan *et al.* (1992) found that cultural methods effectively controlled melon flies and the economic cost benefit ratios were 1 : 9 for ash dusting, 1 : 7.9 for intercropped squash melon as trap crop and 1 : 2.7 for poisoned cut melon baits. Patel (1994) reported that the burial of fallen fruits must be at least at 15cm depth to prevent adult emergence and burial to shallower depths was found to increase survival. The way that cucurbit vines

are trailed may have some effect on pest incidence (Joshi *et al*, 1995). Reghupathy *et al.* (1997) recommended ploughing and turning over of soil after harvest and collection and burying of infested fruits in deep pits. Makhmoor and Singh (1999) found that the mortality of *B. cucurbitae* pupae was 13 per cent at 10cm depth and 93 per cent on the surface.

Host plant resistance is known for the management fruit flies. Some resistance traits were reported in ber (Makhmoor and Singh, 1998; Sharma *et al.*, 1998). Bitterourd resistance to fruit flies is generally weak and is highly vulnerable to fruit fly attack. (Tewetia and Dhankhar, 1996; Thakur *et al.*, 1992, 1994, 1996). It was found that sprays of gibberellic acid and other physiologically active compounds enhanced resistance against fruit flies in mango (Kumar and Singh, 1993; Singh *et al.*, 1995).

2.4.2.2. Mechanical Control

Fang and Chang (1987) reported that protection of fruits by covering excluded the flies from egg laying and complete protection of fruits against fruit flies could be obtained with the use of newspaper bags. Wen (1988) reported that wrapping of of fruits prevented damage by fruit flies. Jalaja (1989) observed that polythene bag was safe, fool proof and economical method for preventing fruit fly damage in bittergourd, compared to cloth or paper bags. However, bagging was an uneconomical practice in commercial cultivation of bittergourd (Nandakumar, 1999). Sivakumar (2001) reported that covering the fruits along with setting up of banana trap or starch – jaggery trap or ocimum - jaggery trap in the field showed zero percent fruit damage.

Palayankodan + carbofuran trap was found effective against fruit flies (Pillai *et al.*, 1991). Nandakumar (1999) reported that banana trap and ocimum jaggery trap were commonly used by farmers. Sivakumar (2001)

reported that fruit fly traps were widely adopted by farmers and the most effective trap was Palayankodan + carbofuran trap.

2.2.4.3. Chemical control

Narayanan and Batra (1960) recommended one per cent malathion emulsion, fenthion or dimethoate with sugar as spray at fortnightly intervals. Studies conducted by Dale (1965) showed that a coarse spray with a liquid bait containing one per cent yeast protein and 0.1 per cent malathion was an effective method to control melon fly without the risk of poison hazard or phytotoxicity. Dale and Nair (1966) found that application of coarse spray of baits was more effective than fine spray. Spraying carbaryl 0.1 per cent three times at fortnightly intervals from the time of flowering was effective against *B. cucurbitae* (David, 1967). Das *et al.* (1968) observed that carbaryl 0.1 per cent, malathion 0.05 per cent and dipterex 0.1 per cent sprays were effective in reducing fruit fly infestation in bittergourd. Fruit fly attack was reported to be lowest when a spray of 0.1 per cent dimethoate or fenthion at tri weekly intervals was applied, commencing from the time of flowering (Nagappan *et al.*, 1971). Mote (1975) reported that tetrachlorvinphos @ 0.1 per cent gave good control of melon fly and also resulted in high yield in bittergourd. He also reported that in cucumber 0.03 per cent fenthion gave better control of fruit flies. Gupta and Verma (1982) had done some evaluations and recommendations for applying baits as sprays. Four spray applications of 0.2 per cent carbaryl were effective against *B. cucurbitae* and resulted in higher yields (Pareek and Kavadia, 1988). In field studies conducted in Rajasthan Malathion 50 EC, 0.5 per cent was found to be the most effective insecticide in reducing the number of *B. cucurbitae* infesting bottlegourd and spongegourd (Bhatnagar and Yadav, 1992). Purcell *et al.* (1994) found that malathion was the most effective insecticide for topical application against fruit flies and Naled was the most toxic insecticide in protein bait tests. In a

study conducted by Talpur *et al.* (1994) in Pakistan, the greatest yield and lowest percentage of incidence by fruit flies was recorded with formothion @ 600ml per acre. Diflubenzuron was found to have ovicidal action on eggs of *B. cucurbitae* damaging cucumber (Mishra and Singh, 1999). Malathion or fenthion @ 0.1 per cent at fortnightly intervals was found to be effective against fruit flies by David (2001). The incidence of fruit flies could be effectively managed by the application of carbaryl or malathion @ 0.2 per cent + sugar as spray along with banana/ ocimum trap (KAU, 2002).

Singh and Srivastava (1983) studied the oviposition deterrence in fruit flies and found that ethanolic extract of neem seed kernel (NSK) at 5 per cent completely deterred oviposition by *B. cucurbitae* in bittetgourd. Neem seed kernel extract and Azadiractin acted as oviposition deterrents against *B. cucurbitae* and *B. dorsalis* (Singh and Singh, 1998). Nair and Thomas (1999, 2001) found that *Acorus calamus* extracts were found to have adverse effects on longevity of fruit flies. They also found that *A. calamus* extracts had chemosterilant and oviposition deterrence effect on *B. cucurbitae*.

Materials and Methods

3. MATERIALS AND METHODS

Studies were conducted in Kalliyoor and Nedinjil area and Instructional farm, College of Agriculture, Vellayani of Thiruvananthapuram district during 2004-2005. The materials used and methodologies adopted are given in this chapter.

3.1 INCIDENCE AND DIVERSITY OF FRUIT FLIES IN THE FIELD

3.1.1 Pest incidence

A survey was conducted in Kalliyoor and Nedinjil area as well as in the Instructional farm, Vellayani during the third crop season (January-April) on fruit fly incidence in snakegourd, bittergourd, pumpkin, cucumber and coccinia. The pest incidence was recorded by selecting plots of size $200m^2$ in each area for sampling. Ten plots, each of $4m^2$ pandal area were marked in each plot at random. The count of total number of fruits and number of infested fruits were taken. The fruit fly incidence was recorded as percentage incidence.

$$\text{Percentage incidence} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits}} \times 100$$

3.1.2 Natural enemies

The natural enemies of fruit flies were recorded. Ten plants were selected at random from the $200m^2$ plots and the parasites and predators present on each plant were recorded.

3.1.3 Assessment of pest status

Laboratory studies were carried out to find out the number of fruit fly larvae harbouring in snakegourd, bittergourd, pumpkin, cucumber and coccinia and to identify different species of fruit flies emerging out of these cucurbits. The lay out of experiment was Completely Randomised Design comprising of five treatments and four replications. Infested fruits

of snakegourd, bittergourd, pumpkin, cucumber and coccinia were collected from unsprayed field of size 200m^2. Infested fruits from five randomly selected plants from the field were taken for rearing. Twenty centimeter diameter glass troughs were used for rearing. Each trough was filled with moist sand to a thickness of three to four centimeters. Infested fruits were kept over moist sand in each trough and was kept in cages of size 2mx 0.5m x 0.5m (Plate 1a.). For each cucurbit four replications were kept. The total number of flies emerged per fruit was recorded for each cucurbit. The different species of fruit flies emerged from the cucurbits were identified based on the key given by Madhura and Verghese (2004).

3.2 BIOLOGY OF *BACTROCERA CUCURBITAE*

The biology of *B. cucurbitae* in the five cucurbits was studied. The experiment was conducted in the laboratory using Completely Randomised Design comprising of five treatments and four replications. Fresh fruit pieces of 5cm length split into two halves were used for snakegourd, bittergourd, pumpkin and cucumber. For coccinia fruits of 5cm length were taken for the study. The fruit pieces were kept in circular glass troughs of 20cm diameter and arranged as described under 3.1.3. Adult female flies were introduced into the cages and allowed to lay eggs on the fruit pieces. The females were removed from the cage 24h after introduction. The egg period and larval period were recorded by destructive sampling. The egg period was noted as number of days from the date of egg laying to the date of larval emergence. The larval period was recorded as number of days from the date of emergence of larvae to the date of pupation. After pupation in soil the fruit pieces were removed. The pupal period was recorded as number of days from the date of pupation till the date of adult emergence. The emerged adults were fed with two per cent honey. Five milliliters of two per cent honey was taken in rectangular plastic trays of size 5cm x 3cm and kept at both ends of the

Plate 1a. Cage used for rearing of fruit flies

Plate 1b. Food baits kept in rectangular tray inside cage

cage. The adult longevity was recorded as the days taken for adult emergence to the death of the adult.

3.3 DOCUMENTATION OF FARMERS' PRACTICES

A survey was conducted based on an approved questionnaire (Appendix I) among 20 randomly selected farmers of Kalliyoor and Nedinjil area of Thiruvananthapuram district. Farmers having area of at least five cents were selected for the survey. The data were collected mainly on cultivation practices adopted, fruit fly management methods, use of fruit fly traps and constraints in the cultivation of cucurbits. The data obtained from the two areas were pooled.

3.4 SCREENING OF FOOD BAITS IN THE FIELD

Screening of food baits was done in snakegourd variety Kaumudi in farmers' field in Kalliyoor area of Thiruvananthapuram district. The trial was carried out during two seasons *viz.*, January to April and June to September. The food bait traps were kept in the field during the peak fruiting periods.

3.4.1 Design of experiment

Randomised Block Design was adopted for the study. Plots of size $40m^2$ were selected for conducting the experiment. Fifteen baits were screened. The bait materials were kept in coconut shells (Plate 2). Each treatment had three replications. The traps were placed at a spacing of 2m x 2m.

3.4.2 Treatments

The experiment comprised of 15 treatments

T1- Robusta (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml)

T2- Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml)

T3- Red banana (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml)

T4- Poovan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml)

T5- Starch (100ml) + jaggery (10g) + yeast (2 granules) + carbofuran (0.5g)

T6- Crushed ocimum leaves (*Ocimum sanctum* L.) (20g) + carbofuran (0.5g) + water (100ml)

T7- Crushed ocimum leaves (*Ocimum sanctum*) (20g) + citric acid (0.5ml) + carbofuran (0.5g) + water (100ml)

T8- Crushed ocimum leaves (*Ocimum sanctum*) (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml)

T9- Powdered dried fish (20g) + carbofuran (0.5 g)

T10- Protein hydrolysate 6.5per cent (100ml) + malathion (0.4ml)

T11- Protein hydrolysate 6.5per cent(100ml) + jaggery (10g) + malathion (0.4ml)

T12- Palayankodan (20g) + jaggery (10g) + carbofuran (0.5 g) + water (100ml)

T13- Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 g) + water (100ml)

T14- Palayankodan (20g) + citric acid (0.5ml)+ carbofuran (0.5 g)

T15- POP recommendation [Palayankodan (slice) (20g) + carbofuran (0.5 g)]

When banana fruits were used along with jaggery, pulp of banana was used.

3.4.3 Observations recorded

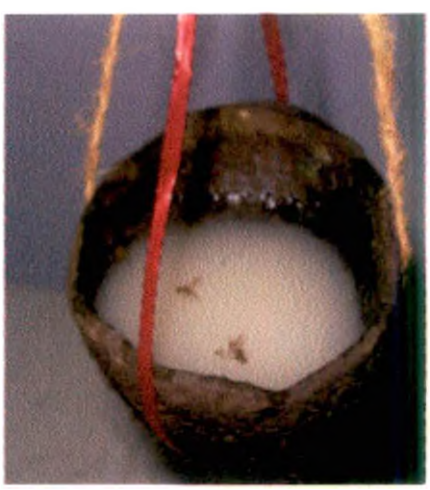
3.4.3.1 Fruit fly catch per day

The fruit fly count was recorded by brushing out the trapped flies on each day. Male, female and total count of fruit flies was recorded separately for each trap.

Banana pulp+ Jaggery + Carbofuran + Water

Palayankodan + carbofuran

Protein hydrolysate +Malathion



Starch + Jaggery + Carbofuran

Plate 2. Various food baits placed in the field in coconut shell

3.4.3.2 Duration of effective trap catch

The duration of effective trap catch was taken as the number of days from the date on which flies were first observed in the trap till the date prior to the date of zero fly catch.

By recording trap catch and duration of effective trap catch the best four traps out of the fifteen traps were selected for cage experiment.

3.5 CAGE EXPERIMENT FOR SELECTING THE MOST EFFECTIVE FOOD BAITS

A cage experiment was conducted in the laboratory for further testing of efficency of the four promising baits selected from the previous experiment.

3.5.1 Rearing of *B. cucurbitae* in the laboratory

The infested fruits of snakegourd were collected from unsprayed fields of size $200m^2$. Infested fruits from five randomly selected plants were collected and the rearing of the flies was done in cage as per the procedure given in 3.1.3.

3.5.2 Selection of most effective baits

A cage experiment was conducted to select two of the most effective baits out of the four selected from the field experiment. Completely Randomized Design was used for the study. The experiment comprised of four treatments with six replications.

The bait material (5ml) was kept in shallow rectangular containers of size 6cm x 4cm (Plate 1b.). Two out of the four baits were kept on both ends of the cage. Twenty freshly emerged adults were released at the centre line. The attraction of flies was noted daily up to the third day. The mortality count of flies in the bait traps were recorded. The traps were rotated so that each bait material was compared against the other three. Based on the attraction the best two out of the four traps were selected.

3.5.3 Determination of temperature of heating jaggery

A cage experiment was conducted to determine the optimum temperature of heating jaggery required for maximum fly catch in the bait material *viz.*, Palayankodan (20g) + heated jaggery (10g) + carbofuran (0.5 g) + water (100ml). The lay out of the experiment was Completely Randomised Design with four treatments and five replications. Jaggery heated at different temperatures *viz.*, 60°C, 80 °C, 100 °C and 120 °C were used. The bait material (5ml) was taken in rectangular plastic trays of size 5cmx3cm. At a time two treatments were kept at both ends of the cage. The treatments were rotated so that each treatment was compared against the other three treatments.

3.6 SELECTION OF TYPE OF CONTAINER

An experiment was conducted in a plot of snakegourd in farmer's field in Kalliyoor Panchayat. The two baits selected from the cage experiment were tested in two containers *viz.*, coconut shell and plastic bottle.Closed plastic bottles of one litre capacity with two windows were used.

3.6.1 Lay out of experiment in the field

The lay out of the experiment was Randomised Block Design with four treatments and five replications. For each replication a plot of size 40m^2 was taken. Coconut shell traps were hung from the pandal by coir ropes and the plastic bottle traps by plastic ropes (Plate 3). Both the types of traps were hung at a height of five feet from the ground. Spacing of the traps was 2m x 2m. The traps were replenished when the duration of effective trap catch was over and it was continued for the entire cropping period.

3.6.2 Observations recorded

The male, female and total fly catches were recorded during the peak fruiting period. The duration of effective trap catch was recorded

as the number of days from the date on which flies were first observed in the trap till the date prior to zero fly catch. The flies were brushed out using camel brush. The other insects that were caught by the trap were also noted. The percentage of incidence and the average yield per plant in the different treatments were recorded.

Five plots each of size $4m^2$ were selected at random from each replication. The count of total number of fruits and number of infested fruits were taken. The fruit fly incidence was recorded as percentage incidence and was calculated.

$$\text{Percentage incidence} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits}} \times 100$$

The average yield per plant in each replication was calculated and expressed in kilograms.

$$\text{Average yield per plant} = \frac{\text{Total yield per plot}}{\text{Total no: plants per plot}}$$

3.6.3 Determination of optimum capacity of plastic bottles

The experiment was laid out in farmer's field in Kalliyoor. It was ensured that the fields selected were free of all insecticide application. The lay out of the experiment was Completely Randomised Design with two treatments and seven replications. The bait material Palayankodan (20g) + boiled jaggery (10g) + carbofuran(0.5 g) + water (100ml) was taken in plastic bottles of capacities 350ml and one litre at the rate of 50ml and 100ml respectively. The spacing of traps was 2m x2m.When 350ml bottles were used 50 ml of bait material was taken and for one litre plastic bottle 100ml of bait material was used. The total count of fruit flies in each trap was taken by brushing out the trapped flies daily.

3.6.4 Determination of optimum size of windows

The experiment was laid out in farmer's field, free of insecticide in Kalliyoor. The design of the experiment was Randomised Block Design

with four treatment and five replications. The bait material [Palayankodan (20g) + boiled jaggery (10g)+ carbofuran(0.5 g) + water (100ml)] was tried in plastic bottles of one litre capacity having two windows each of different sizes *viz.*, 8cm x 4cm, 6cm x 3cm, 5cm x 2cm and 3cmx 1cm. The traps were kept at a spacing of 2m x 2m. The total count of fruit flies in each trap was taken by brushing out the trapped flies daily.

3.7 DETERMINATION OF OPTIMUM SPACING OF TRAPS IN THE FIELD

A field experiment was conducted in the Instructional Farm, Vellayani to determine the optimum spacing of the two selected baits in the best container selected based on the results of the study (para.3.6) (Plate 4).

3.7.1 Raising of snakegourd plants

Snakegourd var. Kaumudi was raised during June- September 2004. The crop was raised with a spacing of 2m x 2m. The recommended package of practices of Kerala Agricultural University (KAU, 2002) was followed except for the plant protection aspects, which were given according to the treatments fixed in this study. Two plants per pit were maintained.

3.7.2 Erection of pandal

Pandal was erected using wooden poles and coir and vines of plants were trailed over the pandal. In the initial stages the vines were supported by coir rope erected from a peg at the base of the plant to the pandal.

3.7.3 Design of Experiment

Randomised Block Design was adopted for the study. Plot of size $60m^2$ was taken as one replication. Observation were not taken from the border plants.

A. Plastic bottle hung from pandal

B. Fruit flies caught in plastic bottle

Plate 3. Food bait traps using plastic bottle

Plate 4. Experimental field for standardisation of trap spacing

3.7.4 Treatments

The experiment comprised of seven treatments with three replications.

Treatments

T1- Selected bait material I (Palayankodan + boiled jaggery + water + carbofuran) at a spacing of 2.5 m x 2.5m

T2- Selected bait material I at a spacing of 3 m x 3m

T3- Selected bait material I at a spacing of 3.5 m x 3.5m

T4- Selected bait material II (Rasakadali + jaggery + water + carbofuran) at a spacing of 2.5 m x 2.5m

T5- Selected bait material II at a spacing of 3 m x 3m

T6- Selected bait material II at a spacing of 3.5 m x 3.5m

T7- Check (POP): Palayankodan + carbofuran in coconut shell at a spacing of 2m x 2m

The bait materials were replaced after the period of effective trap catch determined in the previous experiment (3.6) and the experiment was continued for the entire cropping period.

3.7.5 Observations recorded

3.7.5.1 Fruit fly catch in each trap

The total fruit fly catch in each trap was taken by brushing out the trapped flies daily.

3.7.5.2 Fruit fly incidence

For calculating the percentage infestation of fruits five plots each of size $4m^2$ pandal area were selected at random from each replication. The count of total number of fruits and number of infested fruits were taken. The fruit fly infestation was recorded as percentage

infestation and was calculated during each harvest and the average percentage of infestation was taken.

Percentage infestation = Number of fruits infested X 100
Total number of fruits

3.7.5.3 Yield per plant

The yield per plot was recorded during each harvest. The average yield per plant in each replication was calculated and expressed in kilograms.

Average yield per plant = Total yield per plot
Total no: plants per plot

3.8 POPULATION OF PESTS OTHER THAN FRUIT FLIES AND NATURAL ENEMIES IN THE SNAKEGOURD FIELD

For recording the population of other pests and natural enemies the following procedures were adopted.

Sl.No.	Pests/Natural enemy	Method of observation
1.	Epilachna beetle	Number of grubs in five leaves at random per plant from 10 randomly selected plants
2.	Pumpkin beetle	Total number of adults per plant from 10 randomly selected plants
3.	Leaf feeders	Number of larvae in five leaves at random per plant from 10 randomly selected plants
4.	Spiders	Number of spiders per plant from 10 randomly selected plants
5.	Parasites	Number of parasites per plant from 10 randomly selected plants

3.9 POPULATION OF FRUIT FLY OVER SEASON

The standard fruit fly traps (Palayankodan + carbofuran in coconut shell) were maintained in an untreated snakegourd field in the

Instructional Farm, Vellayani during June – September. Three traps were kept. The bait material in the trap was replaced every week. The male, female and total fruit fly counts were taken and correlated with weather parameters *viz*., temperature, relative humidity, rainfall and number of rainy days (Appendix II).

3.9 STATISTICAL ANALYSIS

Data of each experiment were analysed applying suitable statistical methods of analysis (Panse and Sukhatme, 1985).

Results

4. RESULTS

The results of field and laboratory investigations are given below.

4.1. INCIDENCE OF FRUIT FLIES IN THE FIELD

4.1.1 Pest incidence

A survey was conducted in Kalliyoor and Nedinjil area as well as the Instructional farm, Vellayani during third crop season to document the pest incidence in snakegourd, bittergourd, pumpkin, cucumber and coccinia. The results obtained from the study are presented in Table 1 (Plate 5).

Out of the five cucurbits, bittergourd showed the maximum percentage of incidence both in the Instructional farm and farmers' field and it was significantly higher than that of other cucurbits. Coccinia had the minimum incidence. The incidence of fruit flies in snakegourd and cucumber did not differ significantly. Pumpkin showed a mean percentage of incidence of 24.36 per cent in instructional farm and 27.34 per cent in farmers' field and it was statistically same as that of cucumber.

4.1.2 Natural enemies

Two predatory spiders of *B. cucurbitae viz.*, *Oxyopes shweta* Tikader and *Oxyopes* sp. and a larval pupal parasite of *B. cucurbitae* was identified *viz.*, *Opius* sp. were identified (Plate 6).

4.1.3 Assessment of pest status

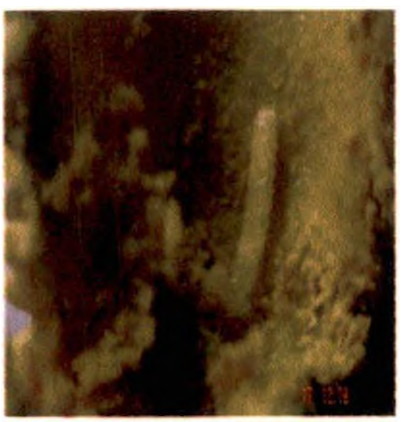
The number of reared out flies per fruit are given in Table 2.

The number of flies emerged from infested fruits of different cucurbits *viz.*, snakegourd, bittergourd, pumpkin, cucumber and coccinia were 108.33, 49.00, 69.00, 44.33 and 14.00 respectively. Snakegourd

Ovipositional exudates on fruit

Rotting of fruit

A. Snakegourd



Maggot feeding inside the fruit

Yellowing and rotting of fruit

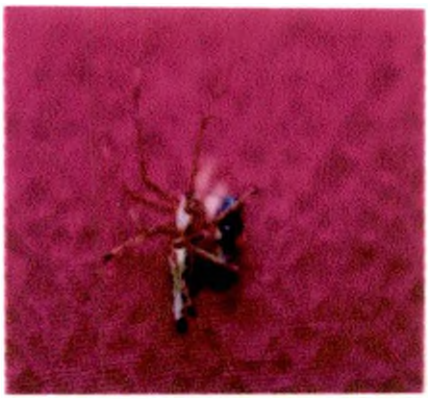
B. Bittergourd

Ovipositional punctures on fruit

Encrustation formed by ovipositional exudates

C. Coccinia

Plate 5. Damage symptoms caused by fruit flies in various cucurbits



Oxyopes shweta Tikader

Oxyopes sp

Opius sp

Plate 6. Natural enemies of fruit fly

Table1. Percentage of fruits infested by fruit flies in different cucurbits

Cucurbit	Percentage infestation	
	Instructional farm	Farmer's field
Snakegourd	30.74 (33.66)	27.87 (31.85)
Bittergourd	45.20 (42.22)	33.38 (35.28)
Pumpkin	24.36 (29.56)	27.34 (31.51)
Cucumber	26.46 (30.96)	26.91 (31.23)
Coccinia	14.90 (22.70)	17.65 (24.23)
CD (0.05)	(3.201)	(2.455)

Figures in parenthesis are angular transformed values

Table 2. Number of flies emerged per fruit in different cucurbits

Cucurbits	Number of flies emerged per fruit
Snakegourd	108.33
Bittergourd	49.00
Pumpkin	69.00
Cucumber	44.33
Coccinia	14.00
CD (0.05)	24.789

recorded maximum fruit fly emergence and coccinia the minimum. These were significantly different from that of other cucurbits. The number of flies emerged did not differ significantly for pumpkin, bittergourd and cucumber.

4.2 BIOLOGY OF *B. CUCURBITAE*

The results obtained from the biology of *B. cucurbitae* in different cucurbits *viz*., snakegourd, bittergourd, pumpkin, cucumber and coccinia are given in Table 3 (Plate 7).

The egg period of *B. cucurbitae* in all the cucurbits did not differ significantly and it ranged from 2.60 – 3.60 days. The larval periods of *B. cucurbitae* the cucurbits were also statistically same and lasted for 9.20 – 12.40 days. Among the pupal periods there was significant difference only between bittergourd (5.13) and pumpkin (6.73). Snakegourd, pumpkin, cucumber and coccinia had a pupal period of 6.00 – 6.73 days. The adult longevity of *B. cucurbitae* adults emerged from coccinia (13.87) was significantly lower compared to those emerged from other cucurbits. The adult longevity of the fruit fly in snakegourd, bittergourd, pumpkin and cucumber were statistically same and ranged from 16.20 – 19.87 days.

4.3 DOCUMENTATION OF FARMERS' PRACTICES

A detailed survey for documenting the farmers' practices, especially for fruit fly management and identifying the constraints in cucurbit cultivation was carried out in two cucurbit cultivating areas viz., Kalliyoor and Nedinjil in Thiruvananthapuram district. The data obtained from the survey is presented in Table 4.

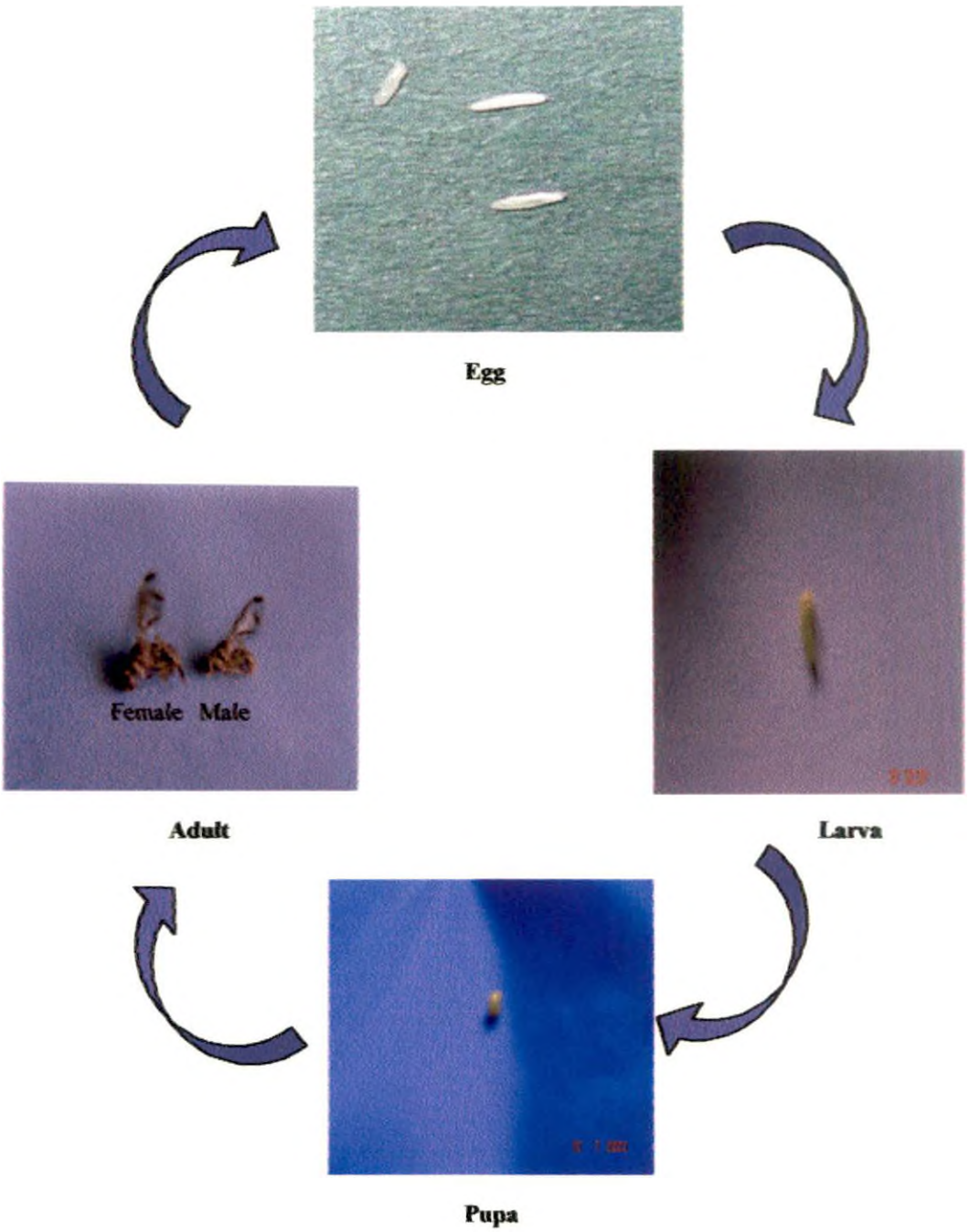


Plate 7. Life cycle of *B. cucurbitae*

Table 3. Biology of *B. cucurbitae* in different cucurbits

Cucurbits	Period of different stages in days			
	Egg	Larva	Pupa	Adult longevity
Snakegourd	2.60	10.40	6.20	19.87
Bittergourd	2.87	12.40	5.13	17.73
Cucumber	3.60	9.20	6.16	16.20
Pumpkin	3.00	10.40	6.73	17.60
Coccinia	2.93	11.13	6.00	13.87
CD (0.05)	NS	NS	1.289	4.438

NS – Not significant

4.3.1 Size of the holding

Total size of holding varied from ten to forty cents. Sixty per cent of the farmers had a holding size of 20-30 cents. Only 15 per cent of the farmers had a holding size above 30 cents. Twenty five per cent farmers' had a land holding of less than 20 cents.

Farmers having vegetable cultivating an area of more than 20 cents constitute only five percent of the total farmers. Eighty per cent of farmers had vegetable area of 10 – 20 cents. Fifteen per cent farmers had vegetable cultivating area less than 10 cents.

About 70 percent of the farmers cultivated cucurbits in an area more than 10 cents. Only five per cent cultivated in an area of less than five cents. Twenty five per cent farmers cultivated cucurbits in an area ranging from five to ten cents.

4.3.2 Nature of land

Majority of the farmers (55 per cent) were cultivating vegetables in wetland. Only 45 per cent were doing vegetable cultivation in garden land.

4.3.3. Crop details

The details of the crop *viz.*, type of cucurbit, variety, source and spacing were collected from farmers.

4.3.3.1 Types of cucurbit

Ninety five per cent of the farmers cultivated coccinia, 90 per cent snakegourd, 80 per cent bittergourd, 40 per cent pumpkin and 20 per cent cucumber.

4.3.3.2. Variety

Improved varieties were widely adopted by farmers. Out of the total farmers 70 per cent used improved varieties and 30 per cent used local varieties.

4.3.3.3 Source of seed material

Sixty five per cent of the farmers used farm saved seeds. Twenty per cent procured seeds from Kerala Agricultural University. Fifteen per cent of the farmers used seeds procured from the neighbouring farmers.

4.3.3.4 Spacing

The recommended spacing for snakegourd is 2.0 x 2.0 m. But only ten per cent of the farmers followed this spacing. Eighty five per cent of the farmers followed a closer spacing than the recommended one. Five per cent of the farmers followed a greater spacing.

4.3.4 Farmers' practices

The details of farmers' practices on pit burning, irrigation, type of nutrient management, fertilizer usage and Farm Yard Manure application were collected from the farmers.

4.3.4.1 Pit burning

Pit burning before sowing the seeds was followed by 55 per cent of the farmers. The remaining 45 per cent did not follow pit burning.

4.3.4.2 Irrigation

Channel irrigation was adopted by 60 per cent of the farmers. The rest 40 per cent farmers followed pot irrigation.

4.3.4.3 Type of nutrient management

Ninety per cent of the farmers followed a combination of organic and inorganic fertilizers. Ten per cent of the farmers followed organic manuring alone. None of the farmers resorted to inorganic fertilizers alone.

4.3.4.4 Fertilizer usage

None of the farmers followed the Package of Practices (POP) recommendations for fertilizer application. Eighty per cent of the farmers followed a dosage above POP recommendations. Twenty per cent of farmers followed a fertilizer dosage below POP.

4.3.4.5 FYM application

All the farmers followed application of Farm Yard Manure (FYM).

4.3.5 Pest management

All the twenty farmers used chemical pesticides. The chemicals were used alone and in combination with botanical commercial formulations. The adoption of botanicals *viz.*, neem oil and nimbecidine was only 20 per cent and ten per cent respectively. Most of the farmers used Malathion (90 per cent), Carbaryl (75 per cent) and Quinalphos (60 per cent). Even high poisonous insecticides like carbofuran (20 per cent) and methyl parathion (10 per cent) were used.

None of the farmers followed POP recommended dosage for application of pesticides. Seventy per cent of the farmers followed a dosage higher than that of the recommended dose. Thirty per cent of the farmers followed a lower dosage.

4.3.6 Fruit fly trap usage

All the farmers used fruit fly trap. Most of them followed banana trap (75 per cent) and Jaggery + carbofuran trap (25 per cent).

Table 4. Details of survey conducted among cucurbits cultivating farmers of Kalliyoor & Nedinjil area of Thiruvananthapuram

Sl. No	Category	Frequency	Percentage
1	**Size of holding**		
	a. Total		
	<20 cents	5	25
	20-30 cents	12	60
	>30 cents	3	15
	b. Vegetables		
	<10 cents	3	15
	10-20 cents	16	80
	>20 cents	1	5
	c. Cucurbits		
	<5 cents	1	5
	5-10 cents	5	25
	>10 cents	14	70
2	**Nature of land**		
	a. Wetland	11	55
	b. Gardenland	9	45
3	**Crop details**		
	a. Types of cucurbit		
	Snakegourd	18	90
	Bittergourd	16	80
	Pumpkin	8	40
	Cucumber	4	20
	Coccinia	19	95
	b. Variety		
	Local	6	30
	Improved	14	70
	c. Source of planting material		
	Own	13	65
	Neighbour farmer	3	15
	KAU/ Agriculture dept.	4	20
	d. Spacing		
	Above POP	1	5
	Same as POP	2	10
	Below POP	17	85
4	**Farmer's practices**		
	a. Pit burning		
	Carried out	11	55
	Not carried out	9	45
	b. Irrigation		
	Channel irrigation	12	60
	Pot watering	8	40

Table 4. (contd)

	c. Type of Nutrient management		
	Organic alone	2	10
	Organic + Inorganic	18	90
	Inorganic alone	0	0
	d. Fertilizer usage		
	Above POP	16	80
	Same as POP	0	0
	Below POP	4	20
	e. FYM application	20	100
5.	**Pest Management**		
	a.Chemicals used		
	Neem oil	4	20
	Nimbecidine	2	10
	Malathion	18	90
	Methyl parathion	2	10
	Quinalphos	12	60
	Carbaryl	15	75
	Carbofuran	4	20
	b.Dosage used		
	Below POP	6	30
	Same as POP	0	0
	Above POP	14	70
6.	**Fruit fly trap Used**	20	100
	Palayankodan + Carbofuran	15	75
	Jaggery + Carbofuran	5	25

4.4 SCREENING OF FOOD BAITS IN FIELD

In the farmer's field fifteen different food baits were tried during two seasons *viz.*, January – April and June – September. The male, female and total fly catch and duration of effective trap catch were recorded.

4.4.1 Fruit fly catch

The results of male, female and total fly catch (*B. cucurbitae*) recorded are given in Table 5.

Male fly catch

During January – April Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) showed significantly higher male catch (4.66) than all treatments except Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran (0.5g) (3.78). During June – August the treatments Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) (4.26), Palayankodan (20g) + jaggery (10g) + carbofuran (0.5 g) + water (100ml) (3.62), Palayankodan (20g) + carbofuran (0.5 g) (4.00), Robusta (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) (2.85) and Red banana (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) (2.96) did not differ significantly with respect to male catch. During this season male catch of the treatment Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g), Palayankodan (20g) + citric acid + carbofuran(0.5g) and Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran(0.5g) were statistically the same.

Female fly catch

During January – April the female count was significantly higher for Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran(0.5g)

(44.94) and Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g) (39.32). The treatments Robusta (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml), Red banana (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml), Poovan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Palayankodan (20g) + jaggery (10g) + carbofuran (0.5 g) + water (100ml) did not differ statistically. During June – August the female count was significantly higher for Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran(0.5g) (48.98), Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g) (33.63) and Palayankodan (20g) + carbofuran (0.5 g) (33.30). The female count in the treatments Robusta (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Poovan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) were on par.

Total fly catch

All banana traps using different banana varieties were significantly superior to other food bait traps with respect to total fly catch in both seasons. In both the seasons the treatments involving Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran(0.5g) (Jan-April- 49.60, June-Aug-53.03), Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g) (Jan-April –43.33, June-Aug- 39.31), Palayankodan (20g) + jaggery (10g) + carbofuran (0.5 g) + water (100ml) (Jan –April - 19.99, June-Aug-33.62) and Palayankodan (20g) + carbofuran (0.5 g) (Jan -April - 15.24, June-Aug- 37.31) recorded significantly higher total fruit fly count. The treatments ocimum leaves (*Ocimum sanctum*) (20g) + carbofuran (0.5g) + water (100ml), ocimum leaves (*Ocimum sanctum*) (20g) + citric acid (0.5ml) + carbofuran (0.5g)+ water (100ml), dried fish (10g) + carbofuran (0.5g), Protein hydrolysate 6.5% (100ml) + malathion (0.4ml) and Protein hydrolysate 6.5%(100ml) + jaggery (10g) + (0. 5g)+ malathion (0.4ml)

Table5. Count of *B. cucurbitae* trapped in different food baits in the field

Treatments	No: of flies trapped per trap					
	January - April			June - August		
	Male	Female	Total	Male	Female	Total
Robusta + jaggery + carbofuran + water	1.49 (1.58)	11.25 (3.50)	12.83 (3.72)	2.85 (1.96)	19.65 (4.54)	22.64 (4.86)
Rasakadali + jaggery + carbofuran + water	4.66 (2.38)	44.94 (6.78)	49.60 (7.11)	4.26 (2.29)	48.98 (7.07)	53.03 (7.37)
Red banana + jaggery + carbofuran +water	1.21 (1.49)	11.64 (3.55)	12.91 (3.73)	2.96 (1.99)	10.61 (3.41)	13.65 (3.83)
Poovan + jaggery + carbofuran + water	1.31 (1.52)	9.65 (3.26)	10.95 (3.46)	2.65 (1.91)	17.33 (4.28)	20.00 (4.58)
Starch + jaggery + yeast + carbofuran	0.63 (1.28)	4.18 (2.28)	4.81 (2.41)	2.61 (1.90)	10.65 (3.41)	13.31 (3.78)
Ocimum leaves + carbofuran + water	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Ocimum leaves + citric acid + carbofuran + water	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Ocimum leaves + jaggery + carbofuran +water	0.00 (1.00)	0.55 (1.24)	0.55 (1.24)	0.63 (1.28)	2.55 (1.88)	3.25 (2.06)
Dried fish + carbofuran	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Protein hydrolysate + malathion	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Protein hydrolysate + jaggery + malathion	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Palayankodan + jaggery + carbofuran + water	2.26 (1.81)	17.65 (4.32)	19.99 (4.58)	3.62 (2.15)	29.96 (5.56)	33.62 (5.88)
Palayankodan + boiled jaggery +carbofuran + water	3.78 (2.19)	39.32 (6.35)	43.33 (6.66)	5.66 (2.58)	33.63 (5.88)	39.31 (6.35)
Palayankodan + citric acid + carbofuran	0.91 (1.38)	13.16 (3.76)	14.25 (3.89)	4.32 (2.31)	23.98 (5.00)	28.30 (5.41)
Palayankodan + carbofuran	1.64 (1.63)	13.54 (3.81)	15.24 (4.03)	4.00 (2.24)	33.30 (5.86)	37.31 (6.19)
CD (0.05)	(0.476)	(0.490)	(0.528)	(0.353)	(0.312)	(0.294)

Figures in parenthesis are $\sqrt{x+1}$ transformed values

showed zero fly catch. When ocimum leaves were used along with jaggery fruit flies were caught in the trap (Jan-April- 0.55, June – August- 3.25). According to the total fly catch in the food baits containing Robusta (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Poovan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) were statistically equally effective for both seasons.

4.4.2. Duration of effective trap catch

The results of effective trap duration are given in Table 6.

The treatment Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g) had significantly higher duration of effective trap catch (Jan -April – 10.67, June-Aug- 11.00). During January – April it was found to be on par with Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml). During the same season the effect of Red banana (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml), Poovan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Palayankodan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) were stastically similar. During June – August, Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml), Palayankodan (20g) + jaggery (10g) + carbofuran (0.5 g) + water (100ml) and Palayankodan (20g) + citric acid + carbofuran (0.5 g) were stastically similar in duration of effective trap catch.

By considering both the total fruit fly catch and duration of effective trap catch Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml), Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 g) + water (100ml), Palayankodan (20g) + jaggery (10g) + carbofuran (0.5 g) + water (100ml) and Palayankodan (20g) + carbofuran (0.5 g) were screened out as superior treatments.

Table 6. Mean duration of effective trap catch in coconut shells containing various food baits

Treatments	Duration of effective trap catch (days)	
	Jan - April	June - Sept
Robusta + jaggery + carbofuran + water	8.33 (3.05)	8.67 (3.11)
Rasakadali + jaggery + carbofuran + water	10.33 (3.37)	10.33 (3.37)
Red banana + jaggery + carbofuran +water	7.33 (2.89)	7.33 (2.89)
Poovan + jaggery + carbofuran + water	5.67 (2.83)	7.33 (2.89)
Starch + jaggery + yeast + carbofuran	3.33 (2.08)	6.00 (2.64)
Ocimum leaves + carbofuran + water	0.00 (1.00)	0.00 (1.00)
Ocimum leaves + citric acid + carbofuran + water	0.00 (1.00)	0.00 (1.00)
Ocimum leaves + jaggery + carbofuran + water	0.33 (1.14)	3.67 (2.16)
Dried fish + carbofuran	0.00 (1.00)	0.00 (1.00)
Protein hydrolysate 6.5% + malathion	0.00 (1.00)	0.00 (1.00)
Protein hydrolysate 6.5%+ jaggery + malathion	0.00 (1.00)	0.00 (1.00)
Palayankodan + jaggery + carbofuran + water	7.33 (2.89)	10.33 (3.37)
Palayankodan + boiled jaggery + carbofuran + water	10.67 (3.41)	11.00 (3.46)
Palayankodan + citric acid+ carbofuran	6.33 (2.71)	10.33 (3.37)
Palayankodan + carbofuran	5.67 (2.58)	7.33 (2.89)
CD (0.05)	(0.140)	(0.159)

Figures in parenthesis are $\sqrt{x+1}$ transformed values

4.5 CAGE EXPERIMENT FOR SELECTING THE MOST EFFECTIVE FOOD BAITS

4.5.1 Selection of promising baits

The results obtained from the cage experiment for the selection of promising baits are given in Table 7.

In the cage experiment the four treatments that were proven to be significantly superior in screening out experiment with respect to total fly catch and duration of effective trap catch *viz.*, Rasakadali (20 g) + jaggery (10g) + water (100ml) + carbofuran (0.5g), Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran (0.5g), Palayankodan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Palayankodan (20g) + carbofuran (0.5g) were used. In the cage experiment Rasakadali (20 g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) having total fly catch of 5.91 and Palayankodan (20g) + boiled jaggery (10g) + water (100ml) + carbofuran (0.5g) having total fly catch of 5.81 were found to be statistically superior to the other two food baits. Both these food baits were statistically equally effective. The treatments Palayankodan (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Palayankodan (20g) + carbofuran (0.5g) were on par and had total fly catch of 3.96 and 4.04 respectively.

4.5.2 Standardisation of temperature of boiled jaggery

The results obtained from the experiment for standardisation of different temperature of boiled jaggery are given in Table 8.

In this experiment jaggery boiled to 60°C, 80 °C, 100 °C and 120 °C were used in Palayankodan + boiled Jaggery trap. The treatment containing jaggery boiled to 80°C had a fly catch of 7.60, which was significantly

Table 7. Mean *B. cucurbitae* catch in traps set under caged conditions

Treatments	No: of flies trapped
Palayankodan + carbofuran	3.96 (1.99)
Palayankodan + jaggery + carbofuran + water	4.04 (2.01)
Rasakadali + jaggery + carbofuran + water	5.91 (2.43)
Palayankodan + boiled jaggery + carbofuran + water	5.81 (2.41)
CD (0.05)	(0.179)

Figures in parenthesis are $\sqrt{x+1}$ transformed values

Table 8. Effect of heating jaggery in food bait on mean *B. cucurbitae* catch

Temperature for heating jaggery (°C)	Fruit fly catch
60	5.60
80	7.60
100	4.00
120	2.80
CD (0.05)	0.907

higher when compared to that at 60°C (5.60), 100 °C (4.00) and 120 °C (2.80). At 120 °C the fly catch was significantly lower.

4.6 STANDARDISATION OF CONTAINERS

The experiment for standardizing container included selection of superior container, standardization of capacity of container and standardization of size of windows.

4.6.1 Selection of superior container

The results obtained from the field experiment for selection of promising baits are depicted in Table 9.

Fruit fly catch

The male catch was significantly higher for Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) in plastic bottle (5.20) when compared to Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g) in plastic bottle and coconut shell. Male catch was significantly lower for Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran (0.5g) in coconut shell.

With respect to female catch Rasakadali (20 g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) in plastic bottle (56.60) was significantly superior when compared to other treatments. A significant reducton in female catch was observed when Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran (0.5g) in coconut shell (21.40) was used.

For Rasakadali (20 g) + jaggery (10g) + water (100ml) + carbofuran(0.5g) in plastic bottle the total fly catch was significantly superior (62.00) when compared to other treatments. Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran (0.5g) in coconut shell

was significantly inferior (22.20) with respect to total fly catch. The total fly catch of Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran (0.5g) in plastic bottle (47.78) was significantly higher than that of Rasakadali (20 g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) in coconut shell (40.60).

Duration of effective trap catch

Palayankodan (20g) + boiled jaggery (10g) +water (100ml) + carbofuran(0.5g) was significantly superior with respect to duration of effective trap catch (14.40) when compared to all the other treatments. The duration of effective trap catch was significantly lower in Rasakadali (20g) + jaggery (10g) + water (100ml) + carbofuran (0.5g) (5.20). The plastic bottles proved to be significantly superior to coconut shell with respect duration of effective trap catch.

Fruit fly incidence

The percentage incidence caused by fruit flies was significantly reduced by Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) in plastic bottle (17.80) when compared to other treatments. The percentage of incidence due to Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5g) + water (100ml) in coconut shell (22.64) was significantly higher than Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) in plastic bottle and coconut shell. The percentage of incidence due to Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5g) + water (100ml) in coconut shell and Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5g) + water (100ml) in plastic bottle did not differ significantly.

Table 9. Effect of different food baits and containers on fly catch, incidence and yield

Treatments	No: of flies trapped/ bottle			Duration of effective trap catch (days)	Incidence (%)	Yield per plant (kg)
	Male	Female	Total			
Palayankodan + boiled jaggery + carbofuran + water in coconut shell	0.80	21.40	22.20	9.20	22.64	14.56
Rasakadali + jaggery + carbofuran + water in coconut shell	3.20	37.40	40.60	5.20	20.64	14.91
Palayankodan + boiled jaggery + carbofuran + water in plastic bottle	2.20	45.40	47.78	14.40	21.40	15.67
Rasakadali + jaggery + carbofuran + water in plastic bottle	5.20	56.60	62.00	11.40	17.80	18.17
CD (0.05)	2.063	5.606	6.439	0.661	1.416	1.022

Yield

The mean yield was significantly higher for Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) in plastic bottle (18.17 kg/ plant). The same food bait when used in coconut shell gave a significantly lower yield of 14.91 kg/ plant. The mean yield was significantly reduced when Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5g) + water (100ml) in coconut shell (14.56 kg/plant) was used. When the same food bait was used in plastic bottle it gave a yield of 15.67 kg/ plant.

4.6.2 Screening different capacity bottles

Plastic bottles of 350ml and 1L capacity were used and the results obtained are given in Table 10.

It was found that 350 ml plastic bottles had significantly more fly catch (50.29) when compared to one litre plastic bottle (43.43).

4.6.3 Standardisation of size of windows

For standardisation of size of windows one litre plastic bottle with food bait Palayankodan (20g) + boiled jaggery (10g) + water(100ml) + carbofuran (0.5g) was used and the results obtained are depicted in Table 11.

Out of the four window sizes tried 6cm x 3cm windows showed significantly higher fruit fly catch (74.00) when compared to 8cm x4cm (41.80), 5cm x 2cm (34.80) and 3cm x 1cm (28.60). Plastic bottles with window size 3cm x 1cm had significantly lower fruit fly catch when compared to the other three. The fly catches in plastic bottles with window sizes 8cm x4cm and 5cm x 2cm differed significantly.

Table 10. Effect of capacity of plastic bottles on mean *B. cucurbitae* catch

Capacity of bottle	No: flies trapped/ bottle
Palayankodan + boiled jaggery + carbofuran in 350 ml bottle	50.29
Palayankodan + boiled jaggery + carbofuran in 1l bottle	43.43
CD (0.05)	6.717

Table11. Effect of window size in plastic bottles on the mean *B. cucurbitae* catch

Size of window	No: of flies trapped / bottle
8cm x 4cm	41.8
6cm x 3cm	74.00
5cm x 2cm	34.80
3cm x 1cm	28.60
CD (0.05)	6.106

4.7 STANDARDISATION OF SPACING OF TRAPS IN THE FIELD

The results obtained from the experiment for standardization of spacing are presented in Table 12.

Total fruit fly catch

Trap containing Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) had significantly higher total fly catch than Palayankodan (20g) + boiled jaggery (10g) + water (100ml) + carbofuran(0.5g) and Palayankodan(20g) + carbofuran(0.5g). It was observed for both the food baits that there was no significant difference in total fly catch when the same food bait was used at different spacing. The control trap Palayankodan (20g) + carbofuran (0.5 g) at 2m x 2m spacing had significantly lower total fly catch (94.67).

Fruit fly incidence

The percentage of incidence of fruit fly in snakegourd was significantly reduced when trap containing Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) was kept at 2.5m x 2.5m (17.67). This was statistically same as the percentage of incidence for Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) at 3m x 3m (21.00) and Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 g) + water (100ml) at 2.5m x 2.5m (2.00). At 3.5m x 3.5m, Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) the percentage of incidence was significantly higher than that recorded at 2.5m x 2.5m. When Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 m) (100ml) was used at 3m x 3m and 3.5m x 3.5m did not differ incidence were 22.67 was used the percentage of incidence was

Table 12. Mean fly catch, percentage incidence and yield in traps set at different spacings

Treatments	Fruit fly catch	Incidence (%)	Yield per plant (kg)
Palayankodan + boiled jaggery + carbofuran + water (2.5m x 2.5m)	135.33	20.00	16.66
Palayankodan + boiled jaggery + carbofuran + water (3m x 3m)	150.33	22.67	15.30
Palayankodan + boiled jaggery + carbofuran + water (3.5m x 3.5m)	159.67	23.00	14.30
Rasakadali + jaggery + carbofuran + water (2.5m x 2.5m)	258.00	17.67	18.32
Rasakadali + jaggery + carbofuran + water (3m x 3m)	261.33	21.00	15.94
Rasakadali + jaggery + carbofuran + water (3.5m x 3.5m)	262.67	22.67	13.99
Palayankodan+ carbofuran (2 m x 2m)	94.67	27.00	11.84
CD (0.05)	30.812	4.650	1.452

significantly increased (27.00). This was found to be on par with that of Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 g) + water (100ml) at 3.5m x 3.5m spacing.

Yield

The yield of snakegourd was significantly superior when trap containing Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) was kept at 2.5m x 2.5m (18.32 kg/plant). The same food bait at 3m x 3m and 3.5m x 3.5m spacing gave a yield of 15.94 kg/plant and 13.99 kg/plant respectively and they were also significantly different. The yield of the crop for the treatment involving Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 g) + water (100ml) at 2.5m x 2.5m (16.66 kg/plant) was statistically same as that of Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) at 3m x 3m. The same trap at 3m x 3m and 3.5m x 3.5m spacing gave a yield of 15.30Kg/plant and 14.30 kg/plant in snakegourd respectively which did not differ significantly. The yield of snakegourd for treatments comprising of Rasakadali (20g) + jaggery (10g) + carbofuran (0.5g) + water (100ml) and Palayankodan (20g) + boiled jaggery (10g) + carbofuran (0.5 g) + water (100ml) at 3m x 3m and 3.5m x 3.5m did not differ significantly. The control trap (Palayankodan (20g) + carbofuran (0.5g) at 2m x 2m spacing) gave a significantly inferior yield of 11.84 kg/plant in snakegourd.

4.8 POPULATION OF OTHER PESTS AND NATURAL ENEMIES IN THE SNAKEGOURD FIELD

The major pests in the field other than fruit flies were leaf eating caterpillars like snakegourd caterpillar (*Anadevidia peponis* (Fabricus)) and pumpkin caterpillar (*Diaphania indica* (Saunders)), leaf feeding beetles like pumpkin beetles (*Aulacophora* spp.) and epilachna beetle

Table 13. Mean weekly population of pests other than fruit flies and natural enemies in snakegourd field

Stage of crop	Number of pests/ plant					Number of natural enemies/ plant	
	Snakegourd caterpillar	Pumpkin beetle	Flower beetle	Epilachna beetle	Pumpkin caterpillar	Spiders	*Opius* sp
3WAS	0.68	0.60	0.00 (1.00)	0.40	0.20	1.8	0.00 (1.00)
4 WAS	1.12	0.80	0.00 (1.00)	0.80	0.76	1.8	0.00 (1.00)
5 WAS	1.20	1.04	0.24 (1.11)	0.60	0.64	4.2	0.4 (1.18)
6 WAS	1.48	1.36	0.60 (1.27)	0.92	0.72	1.8	0.2 (1.09)
7 WAS	1.08	1.24	0.84 (1.36)	0.80	0.92	0.8	2.6 (1.89)
8 WAS	1.08	1.80	0.84 (1.36)	1.12	0.64	2.2	4.8 (2.41)
9 WAS	0.28	0.80	0.26 (1.12)	0.64	0.28	0.8	1.2 (1.48)
10 WAS	0.20	0.92	0.36 (1.66)	0.92	0.24	0.8	0.8 (1.34)
CD (0.05)	0.467	0.449	(0.309)	0.633	0.605	1.082	(0.886)

Figures in parenthesis are $\sqrt{x+1}$ transformed values

WAS – Weeks After Sowing

(*Epilachna septima* Dieke) and flower feeder like flower beetle. The mean weekly populations of these pests are given in Table 13.

The mean population of snakegourd caterpillar was significantly higher during peak vegetative stage (4-8 WAS). The pumpkin caterpillar population was significantly higher during seven weeks after sowing and minimum during three weeks after sowing. The significantly higher population of pumpkin beetle and epilachna beetle were noted during 8 WAS and the populations were 1.80 and 1.12 respectively. The population of flower beetle was zero during 3 WAS and 4WAS and significantly increased during seventh and eighth week after sowing (0.84).

Two predatory spiders of *B. cucurbitae viz.*, *Oxyopes shweta* Tikader and *Oxyopes* sp and a larval pupal parasite of *B. cucurbitae* was identified *viz.*, *Opius* sp. were identified during the field trial. The population of spider was significantly higher during 5 WAS (4.2). The population was significantly reduced during seventh, nineth and tenth weeks after sowing. Population of *Opius* sp. was significantly higher during 8 WAS (4.8) and zero during the third and fourth weeks after sowing.

4.9 POPULATION OF FRUIT FLY OVER SEASON

The fruit fly population was correlated with weather parameters viz., temperature, relative humidity, rainfall and number of rainy days and the results are depicted in Table 14.

It was found that the male, female and total population of fruit flies showed a significant negative correlation with morning relative humidity. There was significant negative correlation between number of rainy days and female and total fruit fly population. Other parameters did not show significant correlation.

Table 14. Correlation coefficients between mean population of fruit fly and weather parameters

Fly population	Temperature (°C)		Relative humidity		Rainfall (mm)	No: rainy days
	Maximum	Minimum	Morning	Evening		
Total	0.3079	-0.0198	-0.6835*	-0.5522	-0.4349	-0.6251*
Male	0.2368	-0.1469	-0.6432*	-0.4489	-0.4073	-0.4543
Female	0.3141	-0.0028	-0.6816*	-0.5601	-0.4339	-0.6411*

* Significant at 0.05

Discussion

5. DISCUSSION

Cucurbits are extensively cultivated in Kerala. Fruit flies are major pests of cucurbits causing considerable economic damage. According to Stonehouse *et al.* (1998) fruit flies caused 10 to 40 per cent damage in cucurbits, which resulted in an annual loss of Rs. 2600 crores in India. Farmers mainly resort to chemical control measures for fruit fly management and the unjudicious use of toxic chemicals results in health hazards and environmental pollution. Under such a situation safer methods like Bait Application Technique have to be popularized. According to Sivakumar (2001) the most commonly used food bait traps were Palayankodan + carbofuran trap, starch jaggery trap and ocimum jaggery trap. An attempt has been made in this study to standardize more efficient baits for ecofriendly fruit fly management.

An earnest effort was taken to increase the bait efficiency by manipulating the ingredients and to reduce the number of bait traps per unit area and thus to reduce the cost of bait application. Cucurbits are comparatively high priced crops and a good quantity is being exported. Hence ecofriendly fruit fly mangement is of much importance. An attempt was made to understand the farmers' practices, to find out the lacunae in their practices and to rectify those defects. Even though the work was mainly carried out in snakegourd, the results obtained are applicable to other cucurbits also.

5.1 INFESTATION OF FRUIT FLIES IN THE FIELD

Bittergourd was more vulnerable to fruit fly attack, compared to other cucurbits *viz.*, snakegourd, pumpkin, cucumber and coccinia. Similar observations were made by Stonehouse *et al.* (1998). This may be due to the large scale cultivation of bittergourd that led to the host adaptability of fruit

flies. The low infestation in pumpkin can be attributed to the hard rind of the fruit, which hinders the female flies from ovipositing on the fruit. Coccinia had significantly minimum percentage of incidence. This may be due to the hardy nature of the crop. Moreover, coccinia is a new host of fruit fly. Earlier its cultivation was limited to homesteads in Kerala. Nowadays its cultivation has increased to commercial level because of its medicinal value and high demand in export market. Varietal variations with regard to the biophysical and biochemical characteristics of the crops often determine the level of susceptibility to infestation by an insect pest. The bittergourd varieties popularly cultivated in the region may be highly susceptible while the other cucurbits may not be so.

Two predatory spiders of *B. cucurbitae viz., Oxyopes shweta* and *Oxyopes* sp and a larval pupal parasite of *B. cucurbitae viz., Opius* sp were observed in the field. *Opius* sp was reported as a parasite of fruit fly by Fullaway (1915), Clausen (1950), Nishida and Bess (1957) and Nair (1995).

The results presented in para 4.1.3 showed that snakegourd had the highest number of flies emerged per fruit is from snakegourd and from coccinia the lowest, compared to other cucurbits. This may be due to the difference in size of fruits. But in pumpkin in spite of its larger size the fruit fly incidence was less. This showed that pumpkin was a less acceptable host of *B. cucurbitae*. The number of flies emerged from fruits gave an indication of pest status in the field. Only *B. cucurbitae* emerged from the infested fruits in all cucurbits. This revealed that only *B. cucurbitae* infested the different cucurbits in the surveyed area. The same species of fruit fly emerged from the infested fruit of different cucurbits and this may be one of the reasons for its status as a major pest.

5.2 BIOLOGY OF *B. CUCURBITAE*

The egg period and larval period of *B. cucurbitae* in the different cucurbits *viz.*, snakegourd, bittergourd, pumpkin, cucumber and coccina did not show significant difference. The pupal period of *B. cucurbitae* was statistically the same in all the cucurbits except pumpkin, which differed significantly from bittergourd. The longevity of adults reared from infested coccinia was significantly lower than that in bittergourd. According to the present study the larval period ranged from 9 – 13 days. But Bhagat and Koul (1999) found that the average larval period of *B. cucurbitae* in different cucurbits was 4.96 days. This may be due to the changes in climatic conditions. Since there was not much variation in duration of life stages of *B. cucurbitae* among the different hosts, any one of the host crops is sufficient for its multiplication in off seasons and can serve as an inoculum in the field. This also indicated the reason for the severity of the pest.

5.2 DOCUMENTATION OF FARMERS' PRACTICES

According to the results presented in para 4.3, 60 per cent of the farmers had a holding size of 20 – 30 cents. Only 30 per cent of the farmers had a holding size more than 30 cents. Because of the fragmented holding it was not easy to take up planned and co-operative pest management practices. Eighty per cent of the farmers cultivated vegetables in an area of 10 – 20 cents. Out of this 70 per cent of the farmers cultivated cucurbits in an area more than 10 cents. This was because of the increasing market value of cucurbits due to their higher demand for culinary purposes and for export. Fifty five per cent of the farmers cultivated in wetland due to the availability of water and ease of intercultural operations.

Among the cucurbits the most widely cultivated one was coccinia. Earlier its cultivation was limited to homesteads in Kerala. Recently its

cultivation has increased to commercial levels due to increase in demand. Coccinia is believed to have anti diabetic properties and is exported to foreign countries. Since it is hardy it is less attacked by major pests of cucurbits especially fruit flies. Moreover, it is perennial and the cost of cultivation is less.

In the surveyed area, the Vegetable and Fruit Promotion Council Keralam has a well established extension network. So the knowledge of farmers on the improved varieties was widespread (70 per cent). But majority of the farmers (65 per cent) resorted to farm saved seeds as it was more economical and did not approach the Kerala Agricultural University or Department of Agriculture for seeds.

Eighty five per cent of the farmers adopted high density planting, adopting a lower spacing than Compared to the recommended spacing of 2m x 2m (KAU, 2002). By adopting high density planting the farmers tried to utilize the available land to the maximum extent possible and get maximum returns per unit area.

Majority of farmers (60 per cent) followed channel irrigation. This was easier and cost effective. Moreover, the farmers used these irrigation channels for dumping the crop wastes and damaged fruits. The farmers were aware of the importance of pit burning, irrigation, fertilizer application and pest management. Bonny (1991) observed that experience in vegetable cultivation had significant positive association with the extent of adoption of improved vegetable cultivation practices. Most of the farmers (90 per cent) were following a combination of organic and inorganic nutrient management. None followed inorganic fertilizer application alone, which showed the awareness of farmers about the ill effects of excess application of inorganic fertilizers alone. Increased cost of inorganic fertilizers may also be one of the factors. But the number of farmers using organic fertilizers only was also less

(10 per cent). This was mainly due to the non availability of organic manures in sufficient quantities. The farmers resorting to organic cultivation fetched very high price in export market.

All the farmers used chemical pesticides. This showed the awareness of the farmers on the importance of pest control. It was observed that 90 per cent of the farmers used malathion for controlling pests. This shows that most of them are aware about the increased mammalian toxicity of other pesticides. But some farmers resorted to the use of highly toxic insecticides like carbofuran during the early stages of the crop. It was observed that there was variation between the recommended practices and the actual practices by the cultivators with respect to quantity of fertilizer and dosage of pesticide. It is significant to note that 70 per cent of the farmers applied chemical pesticide in higher dose than recommended.

Fruit fly traps were adopted by all the farmers. It can be inferred that the farmers considered fruit flies as the most serious pest of cucurbits and took measures to control them. But most of them followed the conventional trap (Palayankodan slice + carbofuran in coconut shell). The problem with this trap is that since it is exposed, the food bait material gets easily dried up in summer and spoiled by water in rainy season. So it is necessary to standardize the use of more promising baits having better fruit fly catch and longer duration of effective trap catch.

5.3 SCREENING OF FOOD BAITS IN THE FIELD

All the traps using different banana varieties as food baits were significantly superior to other food bait treatments with respect to total fly catch (Fig. 1). The use of Palayankodan + carbofuran as a food bait to attract fruit flies was reported by Pillai *et al.* (1991), Nair (1999), Sivakumar (2001) and KAU (2002). Rasakadali + jaggery + water + carbofuran had maximum

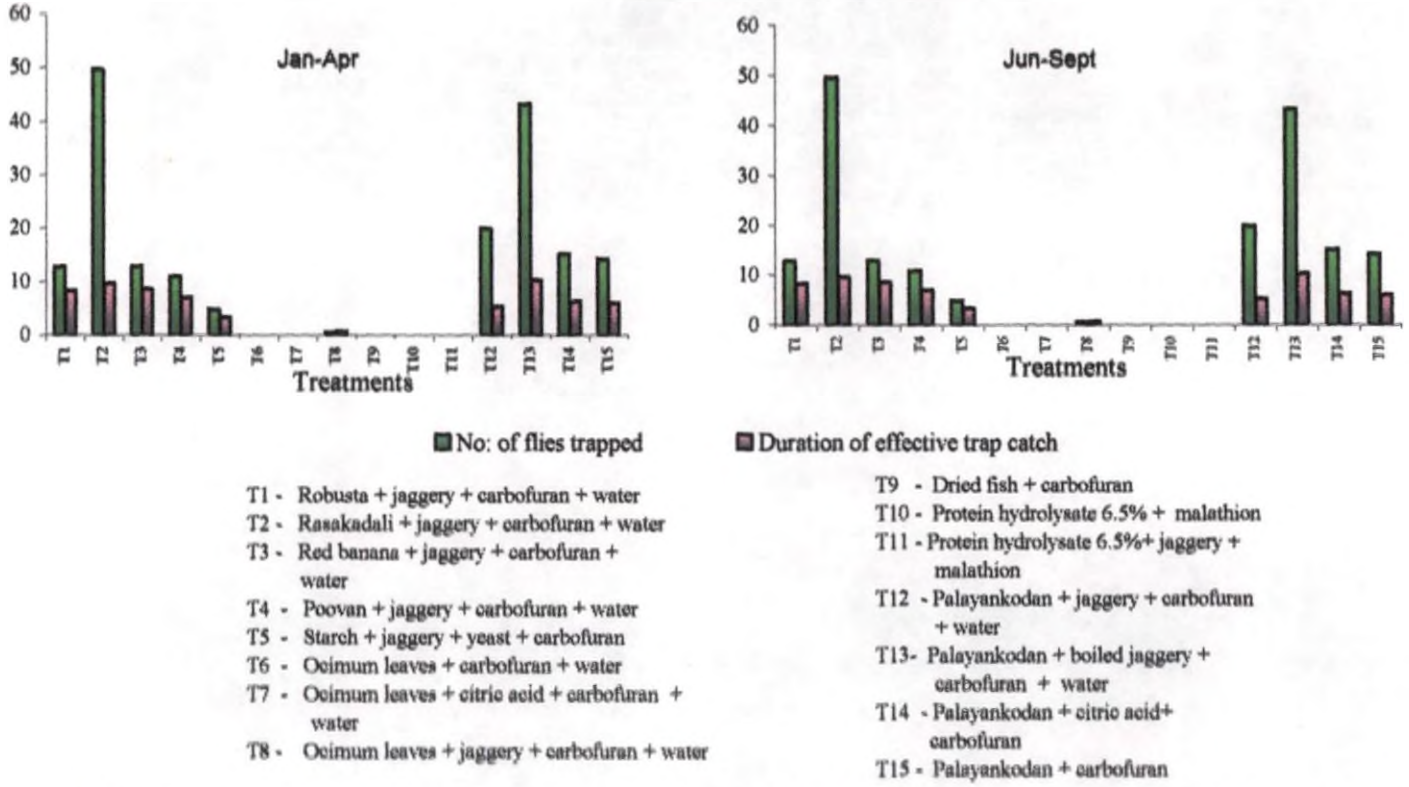
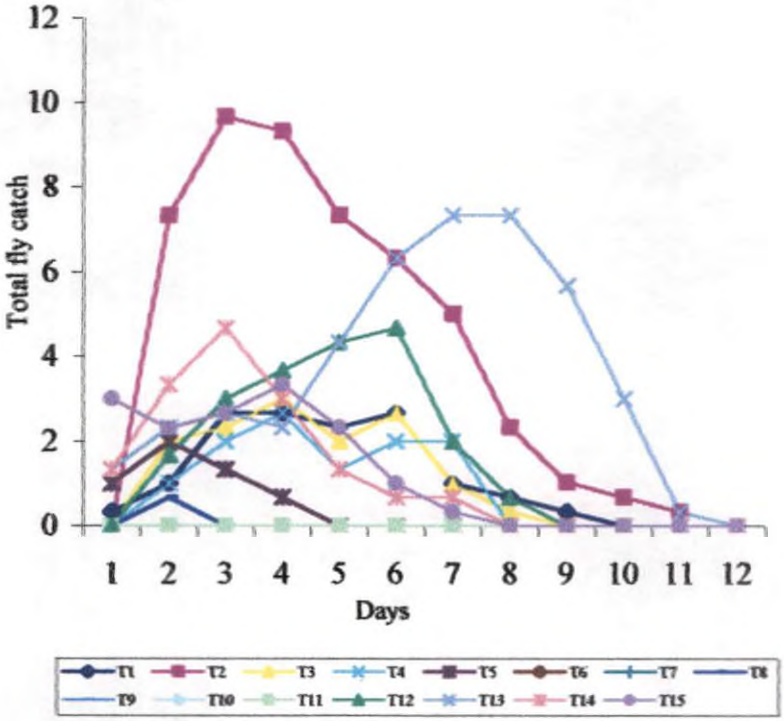


Fig 1. Effect of various food baits on mean trap catch and duration of effective trap catch of *B.cucurbitae*

fly catch compared to the other banana varieties. This may be due to the difference in flavanoid content. Jiji *et al.* (2003b) found that Robusta + jaggery + water + carbofuran recorded the maximum male count and Red banana + jaggery + water + carbofuran had the highest female count. All the treatments involving jaggery were found to attract more flies Sood and Nath (1998) reported that jaggery traps were effective against fruit flies. The traps containing protein hydrolysate (6.5%) did not show any fly catch. But Gupta and Verma (1982) reported that protein hydrolysate could be used for fruit fly adults. Susnandita *et al.* (2001) reported that a mixture of protein hydrolysate (4 %) and boric acid – borax (3:1) was able to attract adults of fruit fly.

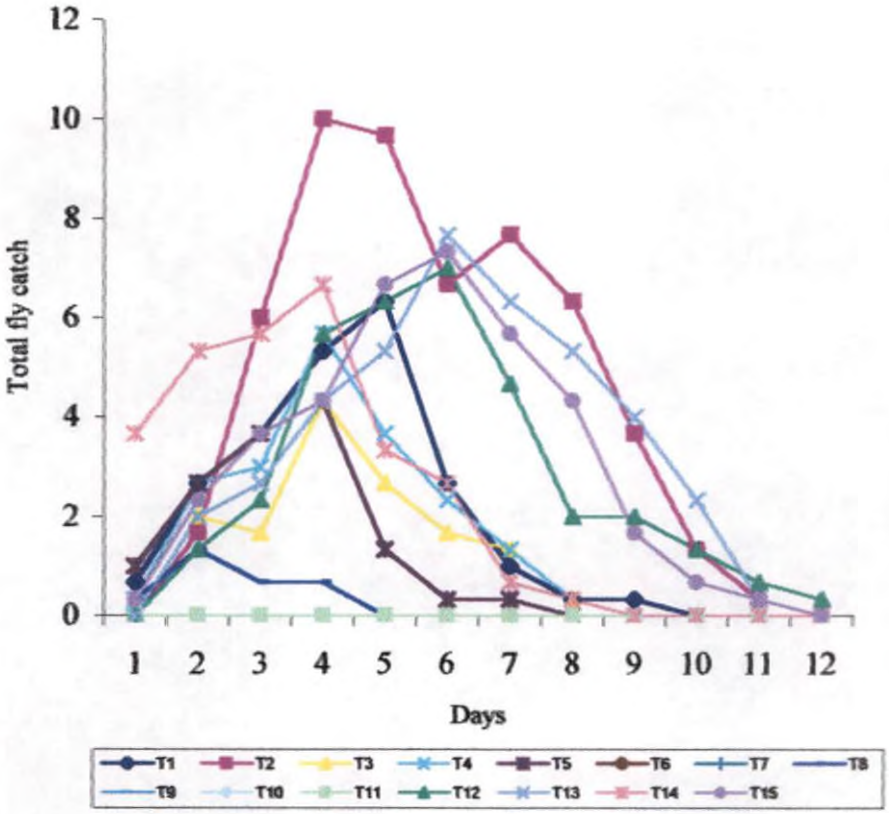
The trap comprising crushed ocimum leaves + jaggery + water + carbofuran attracted *B. cucurbitae* adults. But the same treatment without jaggery did not attract fruit fly adults. This showed that jaggery was an attractant for fruit fly adults. Reghunath and Indira (1993) found that 20g crushed *O. sanctum* leaves, 0.5 g citric acid and 0.5g carbofuran in100ml water placed in coconut shell could attract *B. cucurbitae* and *B. dorsalis*. The trap containing dried fish + carbofuran did not attract flies. However, when wet fishmeal was used it was found to attract fruit flies (Reghupathy *et al.*, 1997).

It was observed that banana traps containing banana fruit + jaggery + water took one or two days to initiate trapping fruit flies (Fig. 2 and Fig. 3). This may be due to the time taken for the banana water mixture to get fermented. The trap containing Palayankodan + boiled jaggery + water + carbofuran had significantly higher duration of effective trap catch. Devikachar (1980) found that jaggery had preservating ability and increased the keeping quality of food materials. Jiji *et al.* (2003b) found that combinations of banana fruit pulp with boiled jaggery were very effective for



T1 - Robusta + jaggery + carbofuran + water
T2 - Rasakadali + jaggery + carbofuran + water
T3 - Red banana + jaggery + carbofuran + water
T4 - Poovan + jaggery + carbofuran + water
T5 - Starch + jaggery + yeast + carbofuran
T6 - Ocimum leaves + carbofuran + water
T7 - Ocimum leaves + citric acid + carbofuran + water
T8 - Ocimum leaves + jaggery + carbofuran + water
T9 - Dried fish + carbofuran
T10 - Protein hydrolysate + malathion
T11 - Protein hydrolysate + jaggery + malathion
T12 - Palayankodan + jaggery + carbofuran + water
T13 - Palayankodan + boiled jaggery + carbofuran + water
T14 - Palayankodan + citric acid + carbofuran
T15 - Palayankodan + carbofuran

Fig 2. Effect of different food baits on fruit fly catch per day and duration of effective trap catch (Jan-Apr)



T1 - Robusta + jaggery + carbofuran + water

T2 - Rasakadali + jaggery + carbofuran + water

T3 - Red banana + jaggery + carbofuran + water

T4 - Poovan + jaggery + carbofuran + water

T5 - Starch + jaggery + yeast + carbofuran

T6 - Ocimum leaves + carbofuran + water

T7 - Ocimum leaves + citric acid + carbofuran + water

T8 - Ocimum leaves + jaggery + carbofuran

T9 - Dried fish + carbofuran

T10 - Protein hydrolysate + malathion

T11 - Protein hydrolysate + jaggery + malathion

T12 - Palayankodan + jaggery + carbofuran + water

T13 - Palayankodan + boiled jaggery + carbofuran + water

T14 - Palayankodan + citric acid + carbofuran

T15 - Palayankodan + carbofuran

Fig 3. Effect of different food baits on fruit fly catch per day and duration of effective trap catch (Jun-Sept)

trapping fruit fly adults and it also increased the keeping quality of the food baits.

5.5 CAGE EXPERIMENT FOR SELECTING THE MOST EFFECTIVE FOOD BAITS

From the result shown in para 4.5.1 in the cage experiment Rasakadali + jaggery + water + carbofuran and Palayankodan + boiled jaggery + water + carbofuran were found to be significantly superior. This was in conformity with the result that was obtained in the field.

According to the result presented in para 4.5.2 heating jaggery at 80°C was found more effective with respect to fly catch. As the temperature of heating jaggery increased above 80°C or decreased below 80°C the trap catch reduced significantly. This may be due to the changes in constituents of heated jaggery at different temperatures.

5.4 STANDARDISATION OF CONTAINERS

As per the results presented in para 4.6.1 plastic bottles were significantly more effective than coconut shells with respect to both total fly catch and duration of effective trap catch. When food baits were kept in capped plastic bottles with windows they were protected from exposure to direct sunlight and rains. They were more economical since they can be repeatedly used for seasons. When coconut shells were used frequent replacements were required because the food bait material in the coconut shells got dried due to direct sunlight or got spoiled by rains. The yield per plant was maximum and percentage incidence was minimum in plots with traps containing Rasakadali + jaggery + water + carbofuran in plastic bottle. This clearly indicated the efficiency of the trap.

Food baits placed in plastic bottle attracted pests other than fruit flies *viz.*, adults of snakegourd caterpillar (*A. peponis*), hairy caterpillar (*Eupterote*

sp.) and fruit moths (*Otheris* sp.). But when the same bait materials were used in coconut shells they could not attract the lepidopteran pests. This can be taken as an additional advantage of using plastic bottles as containers for fruit fly baits in cucurbit fields and can be exploited as an effective and ecofriendly control measure for the lepidopteran pests. However, further studies are to be carried out for standardizing their use for the management of lepidopteran pests.

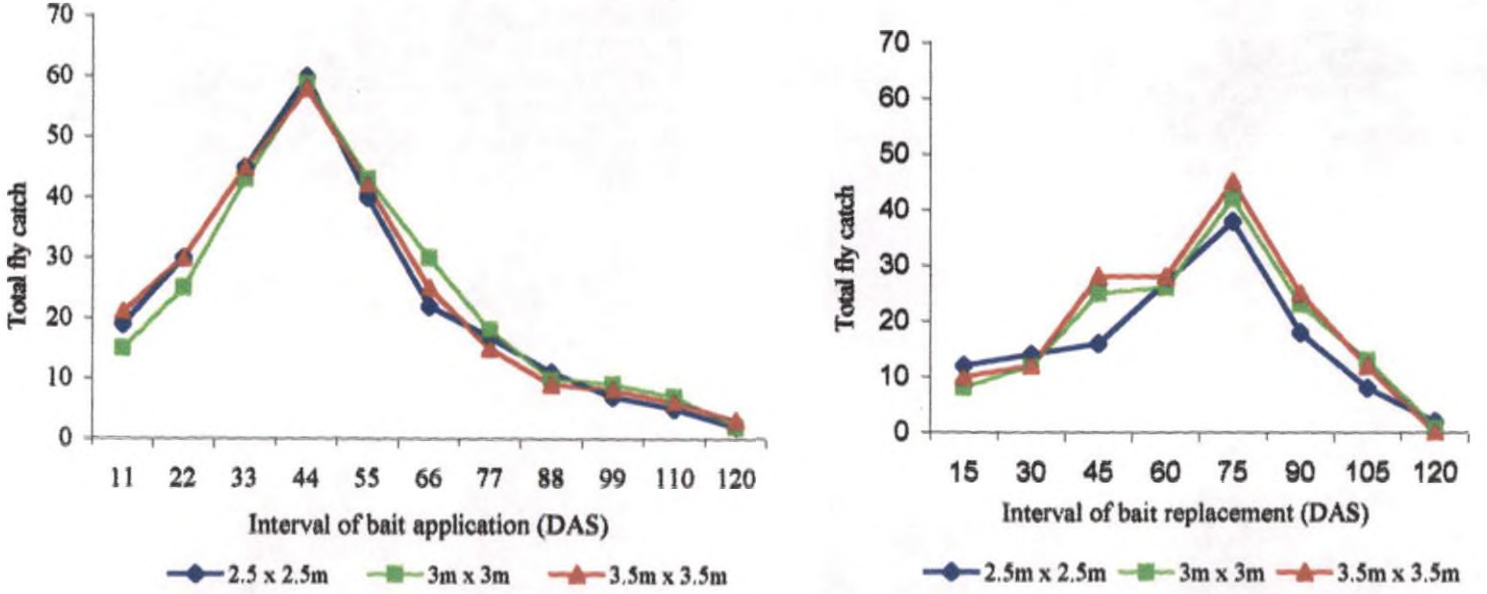
The window size of 6cm x 3 cm was found to be the optimum. When larger sized windows were used more number of lepidopteran pests and less number of fruit flies were trapped. The fruit flies that entered the trap through the larger sized windows found an easy exit, which might have reduced the fly catch. When smaller sized windows were used the catch was less because the small windows hindered the entry of fruit flies.

Bottles of 350ml capacity were more effective than one litre capacity bottles with respect to total fly catch (para 4.6.3). The retention of smell of food bait may be more in smaller bottle. So the fly catch was also more.

5.7 OPTIMISATION OF SPACING OF TRAPS

The lowest fly catch was obtained for Palayankodan + carbofuran traps as compared to all the other treatments. This showed the low efficiency of the Palayankodan + carbofuran trap (POP recommendation). The fruit fly catch was higher for Rasakadali included treatments as compared to Palayankodan included treatments. There was no significant difference in fly catch between the same food bait at different spacings (Fig. 4). So it can be inferred that spacing does not have much influence on fly catch.

The duration of effective trap catch showed significant variations. For Rasakadali + jaggery + water + carbofuran trap the duration of effective trap catch was 11 days. It was replenished 11 times during the whole cropping



A. Rasakadali + jaggery trap (11 replenishments)

B. Palayankodan + boiled jaggery trap (8 replenishments)

Fig. 4 Effect of trap spacing on catch of *B. cucurbitae* in traps using two banana varieties replaced at two intervals

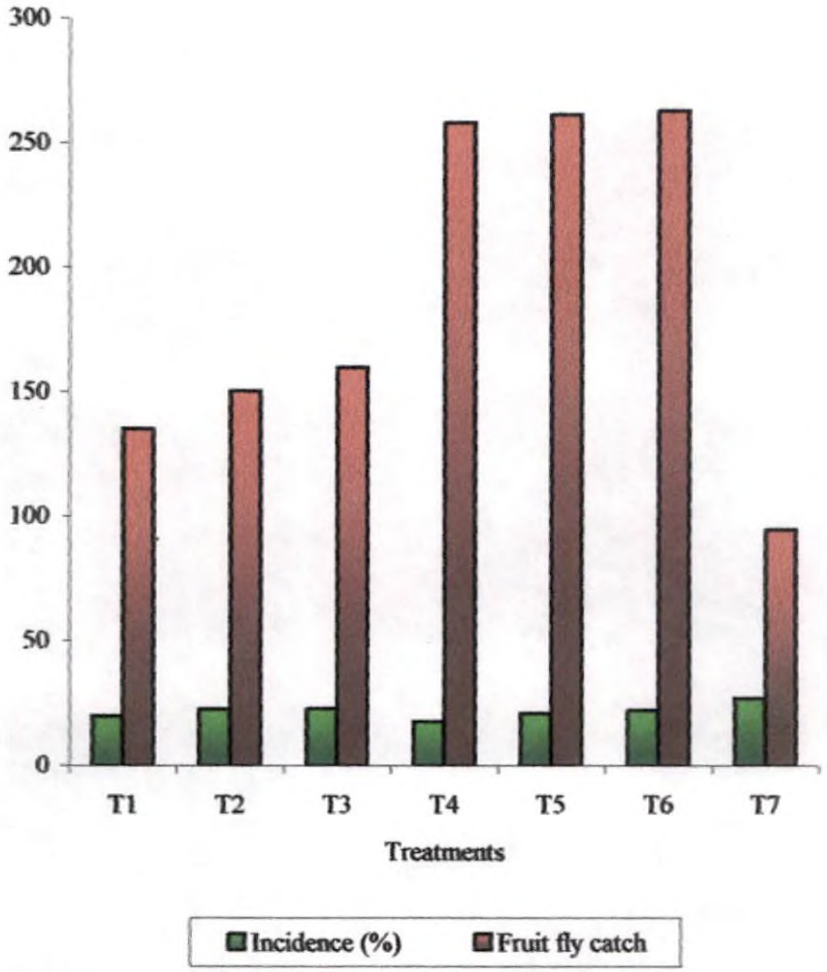
season. For Palayankodan + boiled jaggery + water + carbofuran traps the duration of effective trap catch was 15 days. It was replenished eight times during the whole cropping season. So the number of traps required was less and cost of bait application could be reduced. But for Palayankodan + carbofuran the duration of effective trap catch was only seven days. So the number of replenishments was also more.

The percentage of infestation was significantly higher for plots with Palayankodan + carbofuran trap compared to the other treatments (Fig. 5). The percentage of infestation of fruit fly in snakegourd was significantly lower in the treatments containing Rasakadali and Palayankodan kept at lower spacings. It showed that spacing makes difference in the percentage of incidence of fruit flies. It may be noted that while spacing has no bearing on number of flies trapped in baits, it has influence on the lack of infestaton in plants.

The maximum yield was obtained for treatment involving Rasakadali at 2.5m x 2.5m (Fig. 6). The yield obtained at the same spacing for treatment Palayankodan was significantly lower. Spacing also showed significant difference in yield within the same food bait. As spacing increased the yield decreased.

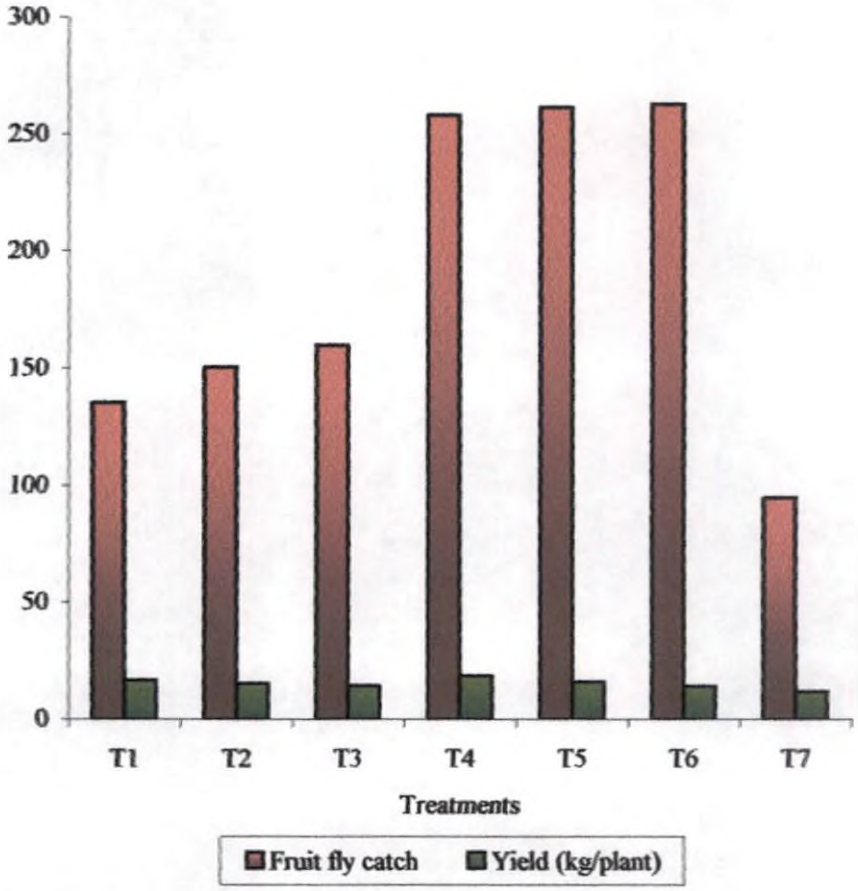
For both Rasakadali + jaggery + carbofuran + water and Palayankodan + boiled jaggery + water + carbofuran, which were found to be the most effective traps in the screening out experiment in the field (para. 4.4) and in the cage experiment (para. 4.5), the number of healthy fruits was always higher than the number of infested fruits (Fig. 7). This confirmed the efficiency of these traps.

With respect to total fly catch, duration of effective trap catch, percentage of fruit fly incidence and yield of crop, the currently



T1- Palayankodan + boiled jaggery + carbofuran + water (2.5m x 2.5m)
T2- Palayankodan + boiled jaggery + carbofuran + water (3m x 3m)
T3- Palayankodan + boiled jaggery + carbofuran + water (3.5m x 3.5m)
T4 - Rasakadali + jaggery + carbofuran + water (2.5m x 2.5m)
T5- Rasakadali + jaggery + carbofuran + water (3m x 3m)
T6- Rasakadali + jaggery + carbofuran + water (3.5m x 3.5m)
T7- Palayankodan+ carbofuran (2 mx 2m)

Fig. 5 Effect of traps set at different spacing on *B. cucurbitae* infestation and catch



T1- Palayankodan + boiled jaggery + carbofuran + water (2.5m x 2.5m)
T2- Palayankodan + boiled jaggery + carbofuran + water (3m x 3m)
T3- Palayankodan + boiled jaggery + carbofuran + water (3.5m x 3.5m)
T4 - Rasakadali + jaggery + carbofuran + water (2.5m x 2.5m)
T5- Rasakadali + jaggery + carbofuran + water (3m x 3m)
T6- Rasakadali + jaggery + carbofuran + water (3.5m x 3.5m)
T7- Palayankodan+ carbofuran (2 mx 2m)

Fig. 6 Effect of traps set at different spacing on *B. cucurbitae* catch and yield in snakegourd field

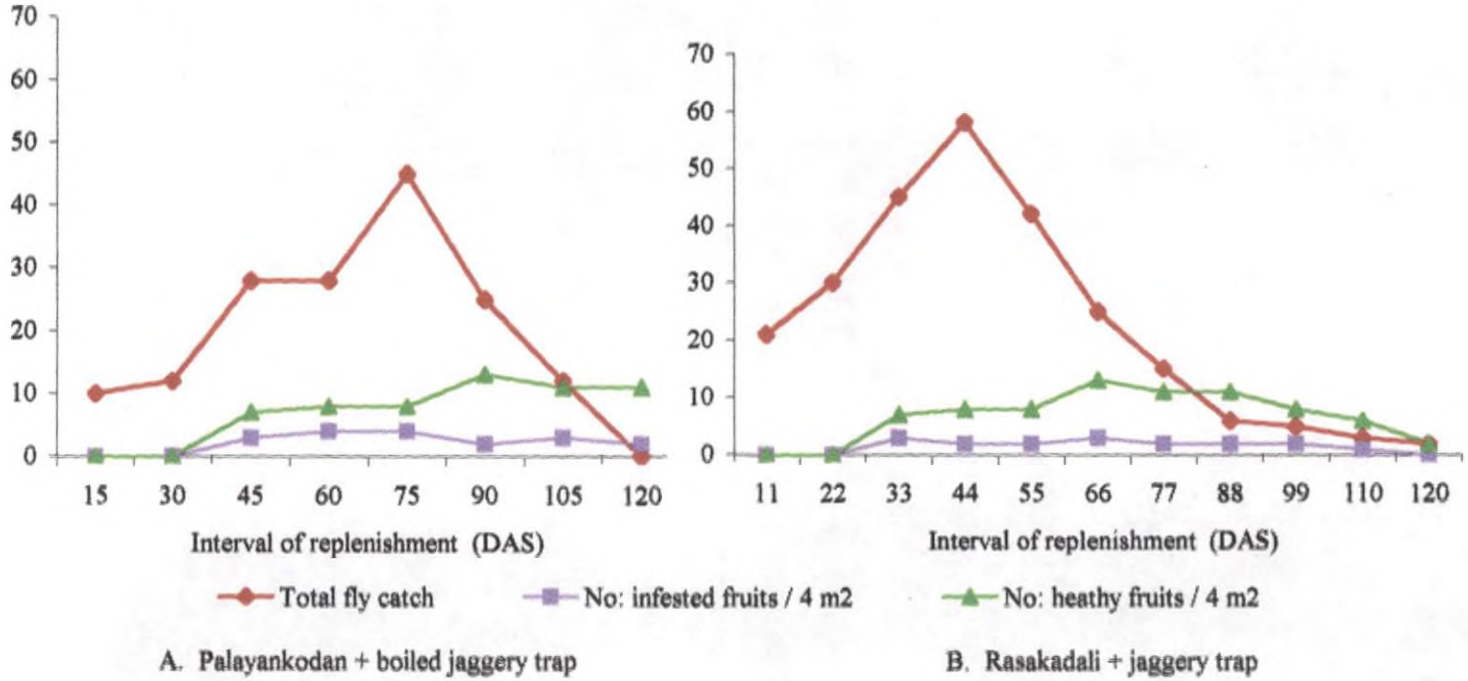


Fig. 7 Fruit fly catch in traps set at 3.5m x 3.5m spacing for fruit fly management replaced at intervals

recommended treatment involving Palayankodan + carbofuran at 2m x 2m was significantly inferior. From the results obtained in the present study a new recommendation involving Rasakadali + jaggery + carbofuran + water or Palayankodan + boiled jaggery + water + carbofuran at higher spacing can be considered. These traps were found to be economical since the number of replacements and number of traps per unit area are less. When the cost of setting up of traps and yield are considered Rasakadali + jaggery + carbofuran + water at 2.5m x 2.5m spacing is the most cost effective.

4.8 POPULATION OF OTHER PESTS AND NATURAL ENEMIES IN THE SNAKEGOURD FIELD

According to the results in para 4.8 the other pests of snakegourd recorded were four foliage feeders and one flower beetle. They were seen in maximum number during peak vegetative stage. Their population decreased as the flowering and fruiting progressed. The population of flower beetle increased with flowering and was maximum during the peak flowering stage. When compared to the fruit fly attack, these pests were less destructive.

When the population of weekly population of fruit fly obtained from the standard trap was plotted with natural enemy population (Fig. 8) the peak population of *Opius* sp coincided with the peak fruit fly population and it showed the positive relationship between the fruit flies and *Opius* sp. But the natural population of *Opius* sp was not sufficient to suppress the fruit fly population to a considerable level. *Opius* sp was reported as a potential larval pupal parasite of fruit flies by Nishida and Bess (1957) and Nair (1995). So, it can be multiplied under laboratory conditions and released to the field for biological control of fruit flies. The number of spiders was maximum during the peak vegetative stage and it did not coincide with the peak fruit fly population. This showed that spiders were general predators and not specific to fruit flies.

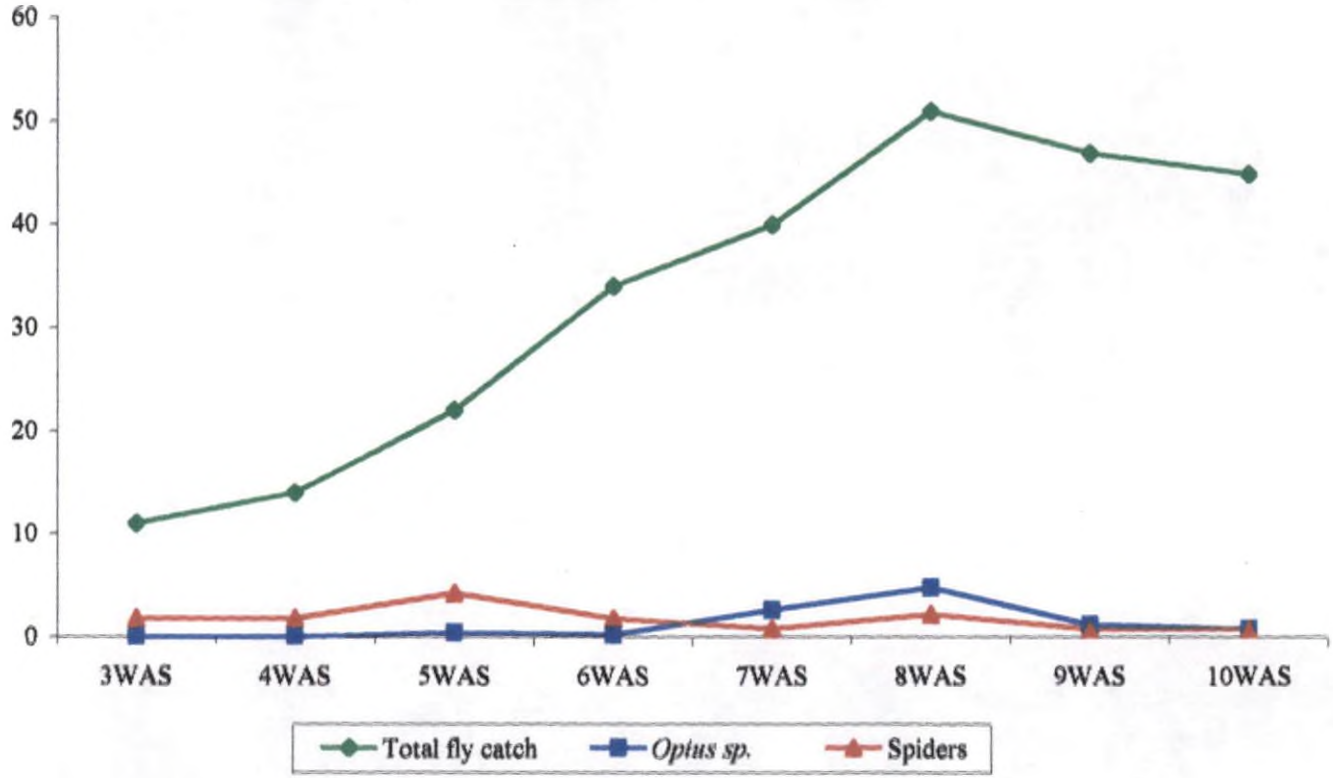


Fig. 8 Mean population of *B. cucurbitae* in relation to population of *Opius* sp. and spiders

5.9 POPULATION OF FRUIT FLY OVER SEASON

The weekly population fluctuations of fruit fly at different stages of snakegourd crop was monitored (Fig 9). The fruit fly catch started from the initial stage of the crop, even before flowering. This showed the existence of fruit flies in the snakegourd ecosystem during early cropping season onwards. The fruit flies might be habitating on alternate host in the crop field or might have migrated from the nearby fields. With the fruit initiation the fruit fly population started increasing considerably. The peak fruit fly population coincided with the peak fruiting. During later stages of the crop the number of infested fruits was more than the number of healthy fruits, which showed the low effectiveness of the standard trap, used by farmers.

Fruit flies are major menace in cucurbit cultivation. There is urgent need for the development of an ecofriendly, cost effective and efficient management measure. The present study shows that Bait Application Technique can be an effective method for the control of fruit flies and can be an important component of integrated management of fruit fly in cucurbits. They are economically feasible, socially acceptable and environmentally safe. The study proved that newer food baits like Rasakadali + jaggery + carbofuran + water or Palayankodan + boiled jaggery + water + carbofuran are effective than the conventional Palayankodan + carbofuran. The plastic bottles were found to be more efficient than coconut shell. The use of these baits are to be popularized among farmers. In conclusion, the study based on cage and field experiments, could identify two bait foods with a better dispenser, which are more efficient than the currently recommended one. Additionally information on incidence and diversity of fruit flies and their natural enemies in the field, biology of *B. cucurbitae* on five cucurbits and details of local practices could be generated.

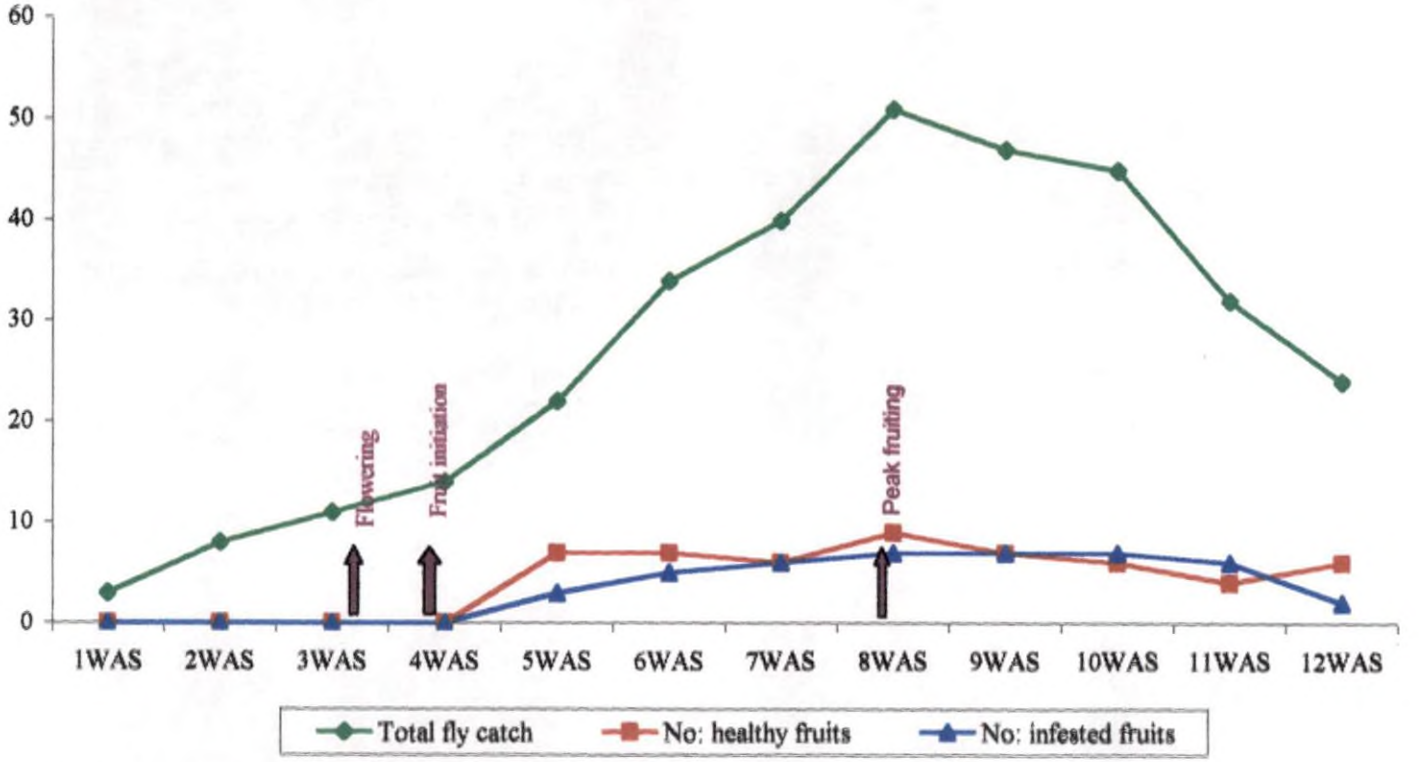


Fig. 9 Natural fly catch in control plot monitored by setting standard trap at weekly interval in relation to healthy and infested fruits

Summary

6. SUMMARY

Cucurbits are extensively cultivated vegetables in Kerala. Fruit flies are major pests infesting these crops. Most of the farmers apply chemical pesticides for the management of fruit flies. Indiscriminate use of hazardous chemicals leads to environmental as well as health problems. The Bait Application Technique is a management method that can be well exploited for the effective management of fruit flies. Although a few food baits are currently in use there can be more promising baits, the use of which has to be standardized and popularized among the farmers for fruit fly management.

A survey was conducted in Kalliyoor and Nedinjil areas as well as in the Instructional Farm, Vellayani during the third crop season (January - April) to assess the incidence and diversity of fruit flies in different cucurbits *viz.*, snakegourd, bittergourd, pumpkin, cucumber and coccinia. The maximum percentage of incidence was recorded in for bittergourd and the minimum in coccinia. The natural enemies recorded from the field were two spiders *viz.*, *Oxyopes shweta* and *Oxyopes* sp. and a larval pupal parasite of fruit flies *viz.*, *Opius* sp.

The pest assessment in the field was done by collecting the infested fruits of five different cucurbits *viz.*, snakegourd, bittergourd, pumpkin, cucumber and coccinia, from unsprayed farmers' fields and rearing out the flies in the laboratory. The number of flies emerged was the highest in snakegourd and the lowest in coccinia. *B. cucurbitae* was the only species of fruit fly emerged during rearing.

The biology of *B. cucurbitae* in snakegourd, bittergourd, pumpkin, cucumber and coccinia was studied. There was not much variation in duration of life stages of insect when reared in five cucurbits.

A survey was conducted in Kalliyoor and Nedinjil areas, the vegetable growing pockets of Thiruvananthapuram district for documenting the farmers' practices especially for fruit fly management. According to the survey 60 per cent of the farmers had an average holding size of 20 – 30 cents. Eighty per cent of the farmers cultivated vegetables per head area being 10 - 20 cents and 70 per cent of the vegetable farmers cultivated cucurbits on an average area of 5 – 10 cents. Fifty five per cent of the farmers preferred wet land cultivation. Ninety five per cent of the farmers cultivated coccinia, ninety per cent snake gourd and eighty per cent bittergourd. Seventy per cent of the farmers used improved varieties. Sixty five per cent of the farmers used farm saved seeds. Recommended spacing was followed by only ten per cent of farmers. None of the farmers followed the recommended dosage for fertilizers and pesticides. Among the chemical pesicides used by farmers malathion was the most popular one (90 per cent). Seventy per cent of the farmers followed pesticide dosage higher than that recommended Package of Practices. All the farmers used fruit fly traps. Seventy five per cent of the farmers used Palayankodan + carbofuran trap.

Out of the fifteen traps screened in fields of snakegourd, cultivated in farmers' field in Kalliyoor, for their efficiency in trapping fruit flies Rasakadali + jaggery + water + carbofuran, Palayankodan + boiled jaggery + water + carbofuran, Palayankodan + jaggery + water + carbofuran and Palayankodan + carbofuran were selected for cage studies. In the cage studies Rasakadali + jaggery + water + carbofuran and Palayankodan + boiled jaggery + water + carbofuran were found significantly superior to all other food baits in attracting fruit flies. Heating jaggery at 80°C increased the duration of effective trap catch.

The two promising baits selected from the cage experiment were tried in two different containers *viz.*, coconut shell and capped plastic bottles

provided with windows. The plastic bottle of 350ml capacity provided with windows of 6cm x 3cm was found superior with respect to total fly catch and duration of effective trap catch. The yield of snakegourd was maximum and the percentage of incidence was the minimum when the bait materials were used in plastic bottles.

The field experiment for optimization of spacing showed that Rasakadali + jaggery + water + carbofuran at 3.5m x 3.5m had the maximum fly catch. The yield was maximum when Rasakadali + jaggery + water + carbofuran was used at spacing of 2.5m x 2.5m. But Rasakadali + jaggery + water + carbofuran required 11 replacements each at 11 days interval throughout the season where as Palayankodan + boiled jaggery + water + carbofuran required only eight replacements each at 15 days interval.

The population of foliage pests in the snakegourd field was the maximum during peak vegetative stage. The peak population of spiders did not coincide with peak fruit fly population. But the population of *Opius* sp increased with the increase in population of fruit flies.

When male, female and total fruit fly populations were correlated with weather parameters it was found that female and total fruit fly populations had significant negative correlation with morning relative humidity and number of rainy days.

The present study revealed that there is an urgent need for popularising Bait Application Technique among the cucurbit cultivating farmers as a major component of integrated management of fruit flies so as to avoid direct application of pesticides on the fruits. The results undoubtedly proved that these traps had longer duration of effective trap catch and required less number of traps and replacements per unit area. The popularization of these results will definitely reduce the cost of cultivation,

improve the quality of the produce, fetch high price in export market and ultimately increase the net returns of the farmers.

References

7. REFERENCES

Agarwal, M.L. and Kapoor,V.C. 1985. On collection of Trypetinae (Diptera : Tephritidae) from North India. *Ann. Ent.* 3: 59-64

Agarwal, M.L. and Kapoor,V.C. 1988. On collection of fruit flies from India. *Bull. Ent.* 29 : 225-228

Agarwal, M.L. and Kumar, P. 1999. Effect of weather parameters on population dynamics of peach fruit fly, *Bactrocera zonata* (Saunders). *Entomon* 24: 81-84

Agarwal, M.L., Sharma, D.D. and Rahman, O. 1987. Melon fruit fly and its control. *Indian Hort.* 32: 10-11

Arora, P.K., Kaur, N., Bàtra, R.C. and Mehrotra, N.K. 1999. Physico chemical characteristics of some ber varieties in relation to fruit fly incidence. *J. appl. Hort.*1: 101-102

Bhagat, K.C. and Koul, V.K. 1999. Seasonal biology of melon fly *Bactrocera cucurbitae* Coq. *J. appl. Zool. Res.* 10: 128-129

Bhatnagar, K.N. and Yadav, S.R.S. 1992. An insecticidal trial for reducing the damage of some cucurbitaceous fruits due to *Dacus cucurbitae* Coq. *Indian J. Ent.* 54: 66.69

Bonny, B.P. 1991. Adoption of improved agricultural practices by commercial vegetable growers of Ollukkara block in Trichur district. MSc. (Ag.) thesis, Kerala Agricultural University, Vellanikkara, Thrissur, p.102

Borah, R.K. 1996. Influence of sowing seasons and varieties on the infestation of fruit fly *Bactrocera cucurbitae* in cucumber in the hill zone of Assam. *Indian J. Ent.* 58: 382-383

Borah, S.R. and Dutta, S.K. 1997. Infestation of fruit fly in some cucurbitaceous vegetables. *J. agric. Sci. Sco. N. E. India* 10: 128-131

Bose, P.C. and Mehrotra, K.N. 1986. Thrust of the ovipositor of fruit fly, *Dacus dorsalis* Hend. *Curr. Sci.* 55 : 1004-1005

Chowdhary, M.K., Malakker, J.C. and Hossain, M.N. 1993. Efficiency of poison bait trap in controlling fruit fly, *Bactrocera cucurbitae* in bittergourd. *Bangladesh J. Ent.* 3: 91-92

*Clausen, C.P. 1950. Biological control of fruit flies. *J. Econ. Ent.* 49: 176-178

Dale, D. 1965. Studies on the relative toxicity of some insecticides to adults of *Dacus cucurbitae* (Coquillett) when used in bait sprays. M.Sc. (Ag.) thesis, University of Kerala, Trivandrum, p.105

Dale, D and Nair, M.R.G.K. 1966. Studies on relative toxicity of some insecticides to adults of *Dacus cucurbitae* (Coquillett) when used as bait sprays. *Agric. J. Kerala* 4: 74-77

*Darz, K.A. and Hashem, A.G. 2003. Biology and life table parameters of peach fruit fly *Bactrocera zonata* (Saunders) reared on different host fruits. *Alexandria J. agric. Res.* 40: 31-37

Das, N.M., Remamony, K.S. and Nair, M.R.G.K.1968. Control of the melon fly *Dacus cucurbitae* (Coquillett) with some newer synthetic insecticides applied as cover sprays. *Agric. Res. J. Kerala* 6 : 43-45

Dashad, S.S., Chaudhary, O.P. and Rakesh, S. 1999. Chemical control of ber Fruit fly. *Crop Res.* 17: 333-335

David, A.L. 1967. Experiment on the control of fruit fly *Dacus cucurbitae* Coq. *S. Indian Hort.* 15 : 64-69

David, B.V. 2001. *Elements of Economic Entomology*. Popular Book Depot, Madras, p.562

Desikachar, H.S.R. 1980. Development of weaning foods with high caloric density and low hot paste viscosity using traditional technologies. *Food Nutr. Bull.* 2: 21-23

Duan, J.J. and Messing, R.H. 1997. Effect of two opine parasitoids (Hymenoptera : Braconidae) introduced for fruit fly control. *Biol. Control* 8: 177-184

*Fang, M.N. and Chang, C.P. 1984. The injury and seasonal occurrence of melon fly and *Dacus cucurbitae* in Central Taiwan. *Pl. Prot. Bull. Taiwan* 26 : 241-248

*Fang, M.N. and Chang, C.P. 1987. Population changes, damage of melon fly in bittergourd garden and control with paper bag covering method. *Pl. Prot. Bull. Taiwan* 29 : 45-57

Farod, A.S. 1996. Developed resistance to fruit fly in ber through hybridization. *ICAR News Sci. Technol. Newsl.* 2: 23

*Fullaway, D.T. 1915. Report of Entomologist. *Rep. Hawaii agric. Stat.* 4: 43-50

Gupta, D. and Verma, A.K. 1993. Biology of *Dacus tau* (Walker) on different vegetable hosts. *J. Insect Sci.* 6: 299-300

Gupta, D. and Verma, A.K. 1995. Host specific demographic studies of the melon fruit fly, *Dacus cucurbitae* Coq. *J. Insect Sci.* 8: 87-89

Gupta, J.N. and Verma, A.N. 1982. Effectivity of fenitrothion bait spray against melon fly , *Dacus cucurbitae* Coq. in bittergourd. *Indian J. agric. Res.* 16: 41-46

Gupta, J.N., Verma, A.K. and Gupta, D. 1992. Population fluctuations of maggots of fruit flies infesting cucurbitaceous vegetables. *Adv. Pl. Sci.* 5: 518-523

Ibrahim, A.G., Palacio, I.P. and Rohani, I. 1994. Biology of *Diachasmimorpha longicaudata*, a parasitoid of carambola fruit fly (Diptera: Tephritidae). *J. trop. agric. Sci.* 17: 139-143

Jalaja, P.N. 1989. Integrated control of fruit fly *Dacus cucurbitae* Coq. (Trypetidae: Diptera) on bittergourd. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p.85

Jalaluddin, S.M., Natarajan, K., Sadakathulla, S. and Balasubramaniyan, S. 1999. Discovery of guava fruit fly *Bactrocera correcta* (Bezzi). *Entomon.* 24: 195-196

Jiji, T., Napolean, A., Naseema, A. and Anitha, N. 2003a. Record of *Aspergillus candidus* link on the fruit fly, *Bactrocera dorsalis* Hendel infesting guava. *Insect Environ.* 9: 81

Jiji, T., Napolean, A.,Stonehouse, J. and Verghese, A. 2003b. Efficient food baits for trapping fruit flies. *Insect Environ.* 9: 143-144

Joshi, V.R., Pawar, D.B. and Lawande, K.E. 1995. Effects of different trailing systems and planting seasons on incidence of fruit fly in bittergourd. *J. Maharashtra agric. Univ.* 20: 290-291

Kapoor, V.C. 1971. New record of fruit fly species from India. *Ent. Newsl.* 1 :19

Kapoor, V.C. 1972. Identification of common fruit flies of India. *Ent. Rec.* 84: 165-169

Kapoor, V.C. 1989. Fruit flies: Their biology, natural enemies and control. *Wld. Crop Pests.* 3: 59-62

Kapoor, V.C. 1993. *Indian Fruit flies.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, p.228

Kapoor, V.C., Agarwal, M.L. and Grewal, J.S. 1976. Identified Indian fruit flies in National Pusa Collection. *Bull. Ent.* 17: 1-15

Kerala Agricultural University. 2002. *Package of Practices Recommendations: Crops.* Twelfth edition. Kerala Agricultural University, Thrissur, p. 278

Khan. L., Inayatullah, C and Ulhaq, M. 1992. Control of melon fly *Dacus cucurbitae* on melon in Pakistan. *Trop. Pest Mgmt* 38: 261-264

Kumar, P. and Singh, S. 1993. Effect of GA3 and ethrel on ripening and quality of mango. *Hort. J.* 6: 19-23

Kumar, S. Patel, C.B. and Bhatt, R.I. 1997. Studies on cyclicity of *Bactrocera correctus* Bezzi. in mango and sapota orchards using methyl eugenol trap. *Gujarat agric. Univ. Res. J.* 22: 68-74

Lakshmanan, P.L., Balasubramoniam, G. and Subramoniam, T.R. 1973. Effect of methyl eugenol in control of the oriental fruit fly *Dacus dorsalis* Hendel on mango. *Madras Agric. J.* 60 : 628-629

Lall, B.S. and Singh, B.N. 1960. A trap for the control of melon fly *Dacus cucurbitae* Coq. *Sci. Cult.* 25 : 541-546

*Liu, T.D., Fang, M.N. and Yang, L.C. 1997. Screening of food attractant on the killing effect of *Bactrocera cucurbitae* Coq. *Bull. Taichung District agric. Improv. Stn.* 56: 35-40

*Liu, Y.C. and Chang, C.Y. 1995. Attraction of food attractants to melon fly, *Dacus cucurbitae* (Coquillett). *Chin. J. Ent.* 15: 69 – 80

*Liu, Y.C. and Hwang, R.H. 2000. The attractiveness of improved molasses attractant to *Bactrocera dorsalis* Hendel. *Pl. Prot. Bull.* 42: 223-233

Madhura, H.S. and Verghese, A. 2004. A guide to identification of some common fruit flies (*Bactrocera* spp.) (Diptera: Tephritidae). *Pest Mgmt hort. Ecosyst.*10: 1-10

Makhmoor, H.D. and Singh, S.T. 1998. Effective concentration of methyl eugenol for the control of guava fruit fly, *Dacus dorsalis* Hendel. *Ann. Pl. Prot. Sci.* 6: 165-169

Makhmoor, H.D. and Singh, S.T. 1999. Effect of cultural operations on pupal mortality and adult emergence of guava fruit fly, *Dacus dorsalis* Hendel. *Ann. Pl. Prot. Sci.* 7: 33-36

Mann, G.S. 1994. Fruit flies as pests of phalsa in Punjab. *J. Insect Sci.* 7: 136-137

Mishra, P.N. and Singh, M.P. 1999. Studies on the ovicidal action of diflubenzuron on the eggs of *Dacus cucurbitae* Coq. damaging cucurbits. *Ann. Pl. Prot. Sci.* 7: 94-96

Mohamed, S.A., Overholt, W.A., Wharton, R.A., Lux, S.A. and Eltoum, E.M. 2003. Host specificity of *Psyttalia cosyrae* (Hymenoptera: Braconidae) and the effect of different host species on parasitoid fitness. *Biol. Control* 28: 155-163

*Mote, U.N. 1975. Control of fruit fly (*Dacus cucurbitae*) on bittergourd and cucumber. *Pesticides* 9 : 36-37

Murthy, J.N.A. and Reghupathy, A. 1992. Seasonal incidence of moringa fruit fly, *Gitona* sp. *S. Indian Hort.* 40: 43-48

Nagappan, K., Kamalanathan, S., Santhanaraman, T. and Ayyasamy, K.K. 1971. Insecticidal trials for the control of melon fly *Dacus cucurbitae* Coq. infesting snakegourd *Trichosanthes anguina. Madras Agric. J.* 58 : 688-690

Nair, M.R.G.K. 1995. *Insects and Mites of Crops in India.* Third Edition. Indian Council of Agricultural Research, New Delhi, p.408

Nair, M.R.G.K. 1999. *A Monograph on Crop Pests of Kerala and their Control.* Third Edition. Directorate of Extension, Kerala Agricultural University, Thrissur, p.227

Nair, S. and Thomas, J. 1999. Evaluation of chemosterilant effect of *Acorus calamus* L. extracts on melon fly, *Bactrocera cucurbitae* Coq. *J. trop. Agric.* 39: 145-148

Nair, S. and Thomas, J. 2001. Oviposition deterrence of *Acorus calamus* L. extracts on melon fly, *Bactrocera cucurbitae* Coq. *J. trop. Agric.* 39: 149-150

Nandakumar, C. 1999. Monitoring and management of the pest complex of bittergourd (*Momordica charantia* L.). Ph.D. thesis, Kerala Agricultural University, Thrissur, p.160

Narayanan, E,S. 1953. Fruit fly pests of orchards and kitchen gardens. *Indian Fmg.* 3: 29-31

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

*Nasiruddin, M. and Karim, M.A. 1992. Evaluation of potential control measure for fruit fly, *Bactrocera* (*Dacus*) *cucurbitae*, in snakegourd. *Bangladesh J. Ent.* 2 : 31-34

Nishida, T. and Bess, H.A. 1957. Studies on ecology and control of *Dacus cucurbitae* Coq. *Tech. Bull. Hawaii Agric. Exp. Stat.*3: 4-6

Panse, V.G. and Suhatme, P.V. 198 . *Statistical Methods for Agricultural Workers*. Fourth Edition. Indian Council of Agricultural Research, New Delhi, 381 p.

Pareek, B.L. and Bhargava, M.C. 2003. Estimation of avoidable losses in vegetable crops caused by borers under semi arid conditions of Rajasthan. *Insect Environ.* 9: 59-60

Pareek, B.L. and Kavadia, V.S. 1988. Economic insecticidal control of two major pests of musk melon, *Cucumis melo*, the pumpkin beetle, *Raphidopalpa* spp. and the fruit fly, *Dacus cucurbitae* in Rajasthan, India. *Trop. Pest. Mgmt* 34 : 15-18

Pareek, B.L. and Kavadia, V.S. 1995. Screening of musk melon varieties against fruit fly, *Dacus cucurbitae* Coq. under field conditions. *Indian J. Ent.* 57: 417-420

Patel, C.B., Patel, K.G. and Saravaiya, S.N. 1996. Dose and efficacy period of methyl eugenol to attract mango fruit fly, *Bactrocera dorsalis* Hendel. *Gujarat agric. Univ. Res. J.* 21: 132-136

Patel, R.K. 1994. Bionomics and control of fruit fly, *Dacus ciliatus* Loew. (Tephritidae: Diptera) infesting littlegourd, *Coccinia indica* Wight and Arnott. Ph.D thesis, Gujarat Agricultural University, Navsari, p.149

Patel, R.K. and Patel, C.B. 1996. Influence of weather parameters on incidence of fruit fly, *Dacus ciliatus* on littlegourd. *Indian J. Ent.* 58: 239-244

Patel, R.K. and Patel, C.B.1998. Combating male fruit flies using Patel fruit fly trap. *Insect Environ.* 4: 52

Pillai, K.S., Reghunath, P., Krishnakumar, R. and Das, N.M. 1991. Relative efficacy of different bait bases for the trapping of the adults of *Dacus cucurbitae*. Coq. *Proc. Kerala Sci. Congr.* (ed. Nair, N.B.), State Committee on Science, Technology and Environment, Thiruvananthapuram, pp.174-175

Project Preparation and Monitoring Cell. 1996. *Comprehensive project for increasing vegetable production to attain self sufficiency in Kerala.* Project Preparation and Monitoring Cell, Government Secreteriat, Thiruvananthapuram, p.85

*Purcell, M.F., Stark, J.D. and Messing, R.H. 1994. Insecticide effect on three tephritid fruit flies and associated braconid parasitoids in Hawaii. *J. Econ. Ent.* 87: 1455-1462

Rahiman, O.A., Reghunath, P. and Prasad, R.M. 1986. Prospects and problems of commercial vegetable growing in rural areas. *Rural Dev. Rev.* 5 : 494-498

Reghunath, P. and Indira, M. 1993. Trapped with holy basil. *ILEIA Newsl.* 3: 31

Reghupathy, A., Palaniswamy, S., Chandramohan, N. and Gunathilagraj, K. 1997. *A Guide on Crop Pests*, Soorya Desktop Publishers, Coimbatore, p.289

Sangwan, M.S. and Lakra, R.K. 1992. Effect of temperature and soil depth levels on pupae of jujube fruit fly, *Carpomyia vesuviana* Costa (Tephritidae: Diptera). *J. Insect Sci.* 5: 80-81

Santhoshkumar, S.R. 1997. Insecticide residues in market sample of vegetables and methods of their decontamination. M.Sc. (Ag.) thesis, Kerala Agricultural University, Vellanikkara, Thrissur, p.104

Sarada, G., Maheshwari, T.U. and Purushothaman, K. 2001. Effect of trap colour, height and placement around trees in capture of mango fruit flies. *J. appl. Zool. Res.* 12: 2-3

Sarode, S.V., Lalitha, P. and Krishnamurthi, P. 1981. Residues of fenthion in musk melon. *J. Entomol. Res.* 5 : 179-181

*Sewoosunkur, G., Zenz, N and Price, N.S. 2000. Local production of protein bait for fruit fly monitoring and control. *Proc. Indian Ocean Commn.* (ed. Seewooruthun, I.). Ministry of Agriculture, Food Technology and Natural Resources, Mauritius, pp. 41-47

Shah, A.H. and Patel, R.C. 1976. Role of tulsi plant (*Ocimum sanctum*) on control of mango fruit fly *Dacus correctus* Bezzi (Tephritidae : Diptera). *Curr. Sci.* 45 : 313-314

Sharma, V.P., Lal, O.P., Rohidas, S.B. and Pramanick, P.K. 1998. Varietal resistance in ber (*Zizyphus mauritiana* Lamk.) against jujube fruit fly, *Carpomyia vesuviana* Costa under field conditions. *J. Entomol. Res.* 22: 61-67

Shukla, R.P. and Prasad, V.G. 1985. Population fluctuations of the oriental fruit fly, *Dacus dorsalis* Hendel in relation to hosts and abiotic factors. *Trop. Pest Mgmt* 31: 273-275

Shukla, R.P., Prasad, V.G. and Tandon,P.L. 1984. Effectiveness of different insecticides against oriental fruit fly, *Dacus dorsalis* Hendel. *Indian J. Hort.* 41: 307-309

Singh, R.P and Srivastava, B.G. 1983. Alcoholic extract of neem (*Azadirachta indica*) seed oil as oviposition deterrent for *Dacus cucurbitae*. *Indian J. Ent.* 45 : 497-498

Singh, S. and Singh, R.P. 1998. Neem (*Azadirachta indica*) seed kernel extracts and azadirachtin as oviposition deterrents against melon fly (*Bactrocera cucurbitae*) and the oriental fruit fly (*Bactrocera dorsalis*). *Phytoparasitica* 26: 191-197

Singh, S., Kumar, P., Brahmachari, V.S. and Singh, D.N. 1995. Effect of pre harvest spray of GA3 and ethrel on storage life of mango. *Orissa J. Hort.* 23: 112-118

Singh, S.P. 1997. Fruit flies and their management. *Indian Hort.* 58: 35-37

Sinha, P. 1997. Effect of culture filtrates of fungi on mortality of *Dacus cucurbitae*. *J. Environ. Biol.*18: 245-248

Sinha, P. and Saxena, S.K. 1999. Effect of culture filtrates of three fungi in different combinations on the development of fruit fly, *Dacus cucurbitae* Coq. *Ann. Pl. Prot. Sci.* 7: 96-99

Sivakumar, T. 2001. Eco-friendly pest management in snakegourd (*Trichosanthes anguina* L). M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p.95

Sood, P. and Nath, A. 1998. Evaluation of insecticide baits for the control of fruit fly, *Bactrocera tau* (Walker) in the mid hills of Himachal Pradesh. *J. Hill Res.* 11: 171-177

Srinivasan, K. 1993. Pests of vegetable crops and their control. *Advances in Horticulture: 6* (eds. Chadha, K.L. and Calloo, G.). Malhotra Publishing House, New Delhi, pp. 860-886

Stonehouse, J., Mumford, J.D. and Mustafa, G. 1998. Economic losses of Tephritid fruit flies (Diptera: Tephritidae) in Pakistan. *Crop Prot.* 17: 159-164

Stonehouse, J., Zia, Q., Mahmood, R., Powal, A. and Mumford, J.D. 2002. Single killing point laboratory assessment of bait control of fruit flies in Pakistan. *Crop Prot.* 21: 647-650

Susnandita, G. and Gupta, D. 2001. Testing of boric acid and protein hydrolysate bait mixture against fruit flies. *Indian J. Ent.* 63: 125-129

*Talpur. M.A., Rustamani, M.A., Hussain, T., Khan, M.M. and Katpar, P.B. 1994. Relative toxicity of different concentrations of Dipterex and Anthio against melon fly, *Dacus cucurbitae* Coq. on bittergourd. *Pakistan J. Zool.* 26: 11-12

*Tewetia, A.S. and Dhankar, B.S. 1996. Inheritance of resistance to melon fruit fly (*Bactrocera cucurbitae*) in bittergourd (*Momordica charantia*). *Indian J. agric. Sci.* 66: 617-620

Thakur, J.C., Khattra, A.S. and Brar, K.S. 1992. Comparative resistance to fruit fly in bittergourd. *Haryana J. hort. Sci.* 21: 285-288

Thakur, J.C., Khattra, A.S. and Brar, K.S. 1994. Stability analysis of economic traits and infestation of melon fly (*Dacus cucurbitae*) in bittergourd (*Momordica charantia*). *Indian J. agric. Sci.* 64: 161-166

Thakur, J.C., Khattra, A.S. and Brar, K.S. 1996. Correlation between economic traits, fruit fly infestation and yield of bittergourd. *Punjab Veg. Grower* 31: 37-40

Vargas, R.I., Stark, J.D., Kido, M.H. Ketter, H.M and Whitehand, L.C. 2000. Methyl eugenol and cue lure traps for suppression of male oriental fruit flies and melon flies (Diptera: Tephritidae) in Hawaii. *J. Econ. Ent.* 93: 81-87

Verghese, A. 1998. Methyl eugenol attracts female mango fruit fly, *Bactrocera dorsalis* Hendel. *Insect Environ.* 4:101

Verghese, A. and Jayanthi, P.D.K. 2001. A convenient polythene sachet trap for fruit flies, *Bactrocera* spp. *Insect Environ.* 6: 193

*Wen, H.C. 1988. Preliminary study on the control of melon fly in the field. *J. Agric. Res. China* 37 : 220-224

*Wesley, W.K. 1956. Major insect pests of vegetables in Allahabad. *Allahabad Fmg.* 30: 136-137

*Original not seen

Appendices

APPENDIX I

PROFORMA FOR DOCUMENTATION OF FARMER'S PRACTICES IN CUCURBIT CULTIVATION

1. Location :
   District :
   Block :
   Panchayat :
   Season :
2. Name of farmer :
3. Address :
4. Size of holding Total :
   Vegetables :
   Cucurbits :
5. Nature of land a)Wetland b)Gardenland
6. Crop details

Crop	Variety	Source	Spacing
Snakegourd			
Bittergourd			
Pumpkin			
Cucumber			
Coccinia			

7. Farmer's practices
   a. Pit burning
   b. Irrigation
   c. Nutrient management
      i) Organic alone
      ii) Organic + Inorganic
      iii) Inorganic alone
   d. Fertilizer usage

Fertilizer used	Quantity
Organic a.FYM b.Poultry manure	
Inorganic a.Urea b.SP/MP c.MOP	

8. Pest management
   a. Chemical control

Chemical	Qty per spray	No. spray	Interval of spray

   b. Fruit fly trap used
9. Constraints in cultivation(if any)

APPENDIX – II

Weather parameters recorded during the growth season of the crop

[from 1WAS to 12 WAS (July – September 2004)

Date	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	No: rainy days
	Maximum	Minimum	Morning	Evening		
Jul 1 – Jul 6	30.30	23.60	93.90	73.70	64.50	4
Jul 7 – Jul 13	29.61	22.80	92.90	76.40	87.40	4
Jul 14 – Jul 20	29.50	22.90	92.60	74.40	153.90	6
Jul 21 – Jul 26	29.70	23.20	94.30	76.40	14.70	6
Jul 27 – Aug 2	29.90	23.10	93.40	76.40	73.60	4
Aug 3 – Aug 9	29.80	22.80	89.60	72.70	6.00	2
Aug 10 – Aug 16	30.20	23.00	88.70	69.90	9.80	3
Aug 17 – Aug 23	30.72	23.52	89.00	67.00	0.00	0
Aug 24 – Aug 30	30.00	22.90	90.60	69.40	33.40	2
Aug 31 – Sept 6	29.40	22.90	93.30	77.60	107.60	5
Sept 7 – Sept 13	30.30	23.90	93.00	76.10	29.30	4
Sept 14 – Sept 20	30.20	23.00	93.00	76.80	22.40	6

EVALUATION OF BAIT APPLICATION TECHNIQUE FOR THE MANAGEMENT OF FRUIT FLIES INFESTING CUCURBITS

VIDYA, L.

Abstract of the
thesis submitted in partial fulfilment of the requirement
for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2005

Department of Agricultural Entomology
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM-695 522

Abstract

A survey conducted in Kalliyoor and Nedinjil areas and Instructional farm, Vellayani for the assessment of pest incidence in the field revealed that among the five cucurbits viz., snakegourd, bittergourd, pumpkin, cucumber and coccinia, bittergourd had the maximum percentage incidence and coccinia the minimum.

Two spiders viz., Oxyopes shweta and Oxyopes sp. and a larval pupal parasite of fruit flies viz., Opius sp. were observed in the field. From the infested fruits of these cucurbits the maximum number of flies emerged from snakegourd and the minimum from coccinia. B. cucurbitae was the only species that emerged from these infested fruits.

The survey conducted in Kalliyoor and Nedinjil areas for documenting farmers' practices showed that majority of the vegetable growing farmers cultivated cucurbits. The farmers were not following Package of Practices recommendations for spacing and fertilizer and pesticide dosages. All the farmers adopted the use of fruit fly traps, especially Palayankodan + carbofuran trap. In the screening experiment in the field, Rasakadali + jaggery + water + carbofuran, Palayankodan + boiled jaggery + water + carbofuran, Palayankodan + jaggery + water + carbofuran and Palayankodan + carbofuran were found to be significantly superior food baits with respect to total fly catch and duration of effective trap catch.

In the cage experiment for selecting two superior baits out of the four baits selected from the field screening trial, Rasakadali + jaggery + water + carbofuran and Palayankodan + boiled jaggery + water + carbofuran were found significantly superior. Heating jaggery to 80oC increased the duration of effective trap catch and keeping quality of food baits. Plastic bottles of

350ml capacity provided with windows of size 6cm x 3cm was found to be the most efficient bait dispenser.

In the field experiment for standardization of spacing Rasakadali + jaggery + water + carbofuran at 3.5m x 3.5m had the maximum fly catch, compared to all the other treatments. However there was no significant difference in fly catch when the same food bait was used at different spacing. The significantly lower percentage of incidence was noted when Rasakadali + jaggery + water + carbofuran was used at 2.5m x 2.5m and 3m x 3m and Palayankodan + boiled jaggery + water + carbofuran at 2.5m x 2.5m. The yield was maximum when Rasakadali + jaggery + water + carbofuran was used at 2.5m x 2.5m.

The population of foliage pests in the snakegourd field was maximum during peak vegetative stage. The peak population of spiders did not coincide with peak fruit fly population. But the population of *Opius* sp increased with the population of fruit flies.

In correlation with weather parameters it was found that female and total fruit fly population had significant negative correlation with morning relative humidity and number of rainy days.

The results of the present study clearly revealed that by the adoption of improved Bait Application Technique profitable production of cucurbits without pesticide contamination is possible.