STUDIES ON FRUIT FLY TRAPPING SYSTEMS BY USING METHYL EUGENOL AND PROTEIN FOOD BAITS IN GUAVA AND MANGO ORCHARDS

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfillment of the requirements for the
Degree of

MASTER OF SCIENCE (AGRICULTURE)

IN

AGRICULTURAL ENTOMOLOGY

By

RAVIKUMAR P.

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
COLLEGE OF AGRICULTURE, DHARWAD
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005

JULY, 2006

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I. INTRODUCTION

Fruit flies are major pests of several fruit and vegetable crops throughout the tropical and subtropical world. Nearly 35 per cent of the known fruit fly species attack soft fruits of which mango, guava, citrus, ber, peach and several cucurbitaceous vegetables are important.

India is the second largest producer of fruits in the world with an annual production of 43 million tons from an area of four million hectares and contributes to more than nine per cent of world's fruit production (Sikhamany and Murti, 2005).

Among various tropical fruits, guava and mango fruits are nutritive and attractive delicious commodities to eat for man. Guava (*Psidium guajova* Linn.) aptly called the apple of tropics is the fourth most important fruit crop in India, with an area of 1.6 lakh hectares and production of 18.50 lakh tonnes (Anon., 2004a). Due to its abundant availability during the season of production, its marketing becomes a serious problem. Delayed harvesting makes it vulnerable to the attack of fruit flies. Mango (*Mangifera indica* Linn.) accounts for 38 per cent of the area and 23 per cent of all the fruits in the country. Both guava and mango are equally attractive to fruit flies.

Fruit flies belong to the family Tephritidae which is one of the largest, most diversified and fascinating acalypterate families of Diptera. Tephritidae includes about 4000 species arranged in 500 genera (White and Elson-Harris, 1992). These are commonly called "fruit flies" due to their close association with fruits and vegetables. Out of 4000 species, 392 species have been recorded in India (Kapoor, 1993).

Fruit flies are of great economic importance as majority of them cause extensive damage to many fruits and vegetables. Female fruit flies lay eggs in fruit and ruin more than 400 different fruits and vegetables including mango, guava, citrus, melon, papaya, peach, passion fruit, plum, apple and star fruit. They are considered as high priority quarantine pests. Because of their infestations, India has been included in the list of those countries from where fruit import to developed countries is banned. In India, a total loss of 2,558 and 26,902 million rupees was estimated due to fruit flies with and without control measures, respectively (Stonehouse, 2001).

Mango and guava are two important fruit crops which are severely damaged by fruit flies. Most common species attacking these two fruits are *Bactrocera dorsalis* Hendel, *B. correcta* Bezzi and *B. zonata* (Saunders) (Verghese and Sudhadevi, 1998 and Rajitha and Viraktamath, 2005d).

Fruit flies deposit their eggs on host fruits when they are physiologically ripe. On hatching, maggots bore their way to the interior and feed on the pulp. Area fed by the maggot is discoloured due to rotting of the fruit and the fruit drops prematurely. Being polyphagous pests with high reproductive potential, wide host range, adaptability to climate and overlapping of generations, their management is rather difficult (Vinodkumar and Agarwal, 1998). Present management strategies mostly focus on chemical insecticides. Due to cryptic nature of the larvae of fruit flies they mostly remain unaffected by such insecticides, *vis-à-vis* the chance of insecticide residues in the fruits also increase.

Sanitation combined with the use of lures and traps as well as baits proved to be the best alternatives for management of fruit flies. These traps have high specificity, low cost and are environmentally quite safe (White and Elson-Harris, 1992; Sureshbabu and Viraktamath, 2003). In India, Rahman *et al.* (1995) discussed the role of baits and attractants in population suppression of fruit flies. Verghese *et al.* (2002) have reviewed management strategies on mango.

Among the various alternate strategies available for the management of fruit flies, the use of methyl eugenol traps stands as the most outstanding alternative. Methyl eugenol has both olfactory as well as phagostimulatory action and is known to attract fruit flies from a distance of 800 m (Roomi *et al.*, 1993). Methyl eugenol, when used together with an insecticide impregnated into a suitable substrate, forms the basis of male annihilation

technique. This technique has been successfully used for the eradication and control of several *Bactrocera* species (Cunningham, 1989).

Continuous research in the development of efficient trapping system afford several new opportunities in the efforts to control the fruit flies. Since adult fruit flies use visual and olfactory stimuli to locate hosts, traps that combine visual and olfactory cues proved to be most efficient for capturing fruit flies (Prokopy and Owens, 1983; Fletcher and Prokopy, 1991).

The responses of the fruit flies to visual stimuli are dependent on colour, shape and size of the stimulus (Katsoyannos, 1989). These findings have opened new avenues in increasing efficiency of traps by altering the design and choosing the most suitable shape, size and colour.

Female fruit flies are the dominant factor for multiplication. Female attractive baits are needed in any applicative system against this pest for monitoring and direct control (Mazor *et al*., 2002).

Female fruit flies need protein source to mature sexually and also for the development of their eggs (Christenson and Foote, 1960). Female targeted system normally consists of traps baited with a liquid solution made from protein and fermenting sugar (Epsky *et al*., 1999).

Increasing knowledge on behaviour associated with attraction of both sexually immature females and egg laying females would improve detection and delimitation of fruit flies and provide increased protection of crops adversely affected by their presence. It is envisioned that further optimization of visual cues and trap design might evolve.

Keeping these observations in view, present investigations on “Studies on fruit fly trapping systems by using methyl eugenol and protein food baits in guava and mango orchards” was undertaken with the following objectives.

1. To evaluate on the quantity and frequency of charging of the traps with methyl eugenol in guava and mango orchards
2. To evaluate on the efficacy of different coloured traps in capturing fruit flies in guava and mango orchards
3. To evaluate on the efficacy of different shapes of traps in capturing fruit flies in guava and mango orchards
4. To evaluate different protein food baits in attracting female fruit flies
5. To monitor the incidence of different species of fruit flies using methyl eugenol traps in guava and mango orchards
6. To study the influence of weather parameters on trap catches in guava and mango orchards

II. REVIEW OF LITERATURE

Review of literature pertaining to evaluation of different quantities and frequency of charging with methyl eugenol, efficacy of various coloured traps, different shapes of the traps, evaluation of protein food baits, monitoring and relationship between trap catches and weather parameters are presented in this chapter.

2.1 EVALUATION ON THE QUANTITY AND FREQUENCY OF CHARGING OF THE TRAPS WITH METHYL EUGENOL IN GUAVA AND MANGO ORCHARDS

Methyl eugenol, a parapheromone is known to attract 69 species of fruit flies (Drew, 1974; 1989; Drew and Hancock, 1994) and it is being widely used for male annihilation technique for management of *Bactrocera* spp (White and Elson Harris, 1992). Drew *et al*. (1982) recommended use of dichlorovos along with methyl eugenol for successful kill of fruit flies.

Balasubramaniam *et al*. (1972) and Lakshmanan *et al*. (1973) reported that 1 per cent methyl eugenol along with 0.5 per cent malathion or 0.1 per cent carbaryl is most effective against *B. dorsalis*. They advocated monthly replenishment of methyl eugenol. However, Cunningham *et al*. (1975) used 83 per cent methyl eugenol along with 10 per cent naled and 7 per cent thixein for management of *B. dorsalis*.

Belavadi (1979) tested 0.025, 0.05, 0.075 and 0.1 ml of methyl eugenol impregnated on 2 cm^2 cotton wad and found no significant differences in the efficacy when replenished at weekly interval. Under field conditions he observed that single application of methyl eugenol at 0.075 ml was most effective up to 17 days for capturing *B. dorsalis* fruit flies if the population is low (0-22 fruit flies/trap) and upto 32 days when the population is high (0-81 fruit flies/trap).

Liu (1991) showed that 10 per cent (mixture of 10% methyl eugenol and 90% cue lure) and 20 per cent MC (mixture of 20% methyl eugenol and 80% cue lure) attracted more number of fruit fly than methyl eugenol alone.

Liu and Lin (1992) showed that 10 per cent MC was effective lure for *B. cucurbitae*. Singh (1993) reported a significant reduction in the *B. dorsalis* population by using 0.1 per cent methyl eugenol baited traps in the guava orchard.

According to Makhmoor and Singh (1998) 1 per cent concentration of methyl eugenol was significantly superior to all other treatments for the control of guava fruit fly *B. dorsalis* in guava orchard.

Madhura (2001) reported that 100:0 and 90:10 ratio of methyl eugenol and cue lure attracted the maximum number of fruit flies compared to other proportions.

It is recommended to use 0.1 per cent solution of methyl eugenol for trapping fruit flies in mango and guava (Anonymous, 2004b).

2.2 EVALUATION ON THE EFFICACY OF DIFFERENT COLOURED TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

Fruit flies use a number of visual cues to locate hosts and appropriate visual cues may be highly attractive to these fruit flies (Prokopy, 1968a).

More *Ceratitis capitata* (Wiedemann) were captured on yellow rectangles than light orange, light green, red grey or clear rectangles (Prokopy and Economopoulos, 1976).

Greany *et al.* (1977) found that fluorescent orange rectangles were the most effective for capture of Carribbean fruit fly, *Anastrepha suspensa*(Loew).

Prokopy (1977) opined that 7.5 cm sticky coated red spheres attracted more *Rhagoletis pomonella* (Walsh). According to Nakagawa *et al.* (1978), 7.5 cm spheres of black and yellow coloured traps captured more females of *C. capitata* and red, orange and yellow traps captured more males.

Though the use of male attractants has been one of the common procedures for monitoring, some workers opined that visual cues play an important role in host finding behaviour of fruit flies (Prokopy and Owens, 1983; Fletcher and Prokopy, 1991). Responses of the fruit flies to visual stimuli were dependent on the colour shape and size of the stimulus (Katsoyannos, 1989; Economopoulos, 1989).

Green, yellow and orange were the most attractive colours for the Mexican fruit fly, *A. ludens* (Loew) (Robacker *et al*., 1990). Sivinski (1990) found that more *A. suspensa* were captured on 20 cm diameter orange spheres than spheres that were smaller or different coloured. Bressan *et al.* (1991) found that spherical yellow traps were more attractive to *Anastrepha* spp. followed by green cylindrical traps.

Capture of oriental fruit fly, *B. dorsalis* was higher on yellow and white 4 cm spheres than on orange, red, light green, dark green and black spheres in guava orchard (Vargas *et al*., 1991). Stark and Vargas (1992) reported that male oriental fruit fly responded more to white and yellow coloured plastic bucket traps than green, red and black.

Epsky *et al.* (1995) found highest capture of *C. capitata* in green 3 hole traps with dull exteriors and with 12-15 cm width visual cue than on shiny orange traps. In tests of clear traps versus traps with a painted colour strip (~7.5 cm high) around the periphery of the middle to provide a visual cue, more females and males of *C. capitata* were captured in green and yellow traps respectively (Heath *et al*., 1995). Use of a fluorescent yellow or orange colour insert instead of white insert in Jakson traps increased *C. capitata* capture (Epsky *et al*., 1996). Heath *et al.* (1996) observed that width of the visual cue affected percentage capture of *C. capitata* females and traps with 12-15 cm width green visual cue captured more female fruit flies. Greater captures of *C. capitata* were achieved with orange and yellow bucket traps and orange modified bucket traps (Uchida *et al*., 1996).

In another study by Jalaluddin *et al.* (1998) orange and yellow coloured traps attracted more *Bactrocera* spp. in Tamil Nadu.

Liburd *et al.* (1998) observed that baited green, red, yellow or blue spheres were more attractive to blue berry maggot, *R. mendax* (Walsh) than baited yellow board traps in V orientation.

According to Cornelius *et al.* (1999) standard Ladd traps attracted more *B. dorsalis* females because of the visual contrast of red spheres against a light yellow background. Similarly Alyokhin *et al.* (2000) reported Ladd trap as the most attractive visual trap for oriental fruit flies.

Mayer *et al.* (2000) obtained more trap catch of cherry fruit fly, *R. indifferens* (Curran) on 10 cm red spheres followed by 8 and 12 cm, compared to vertical and V oriented yellow rectangles.

Katsoyannos and Kouloussis (2001) reported that yellow and orange 70 mm diameter plastic spheres, coated with adhesive, trapped the greatest number of male *B. oleae* (Gmelin) while red and black spheres trapped more females. Robacker and Heath (2001) opined that yellow sticky traps without mesh captured six times more Mexican fruit flies than green traps.

In another study conducted in Bangalore, Madhura (2001) found that deep yellow colour traps attracted maximum number of *Bactrocera* spp.

Sarada *et al.* (2001a) observed that significantly more number of *B. dorsalis*, *B. correcta* and *B. zonata* were attracted to white (16.95 files/trap/week) and yellow (15.31 fruit flies/trap) coloured traps followed by green, orange, red and blue, respectively.

Rajitha and Viraktamath (2005a,b) reported that medium (500 ml) transparent bottle in guava and orange and green sphere in mango were the efficient traps against *B. dorsalis*. *B. correcta* was attracted to green cylinder and red sphere in guava and orange and green sphere in mango, while, *B. zonata* to red and transparent bottle traps in mango.

2.3 EVALUATION ON THE EFFICACY OF DIFFERENT SHAPES OF TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

Boller (1969) opined that spheres might be more attractive as they could be visible by the fruit flies from all direction. However, significant preferences of discs over rectangles of same surface suggested that *per se* is an important cue and that fruit flies may detect and prefer spheres over other shapes partly (Prokopy, 1968a). The biological basis for the acceptance of spheres over the other shapes may be due to similar shape of the oviposition hosts.

Most of the earlier work was concentrated on comparing the response of *R. pomonella* (Prokopy, 1966), *R. cerasi* (Weismann, 1937; Prokopy and Boller, 1971), *R. complita* (Cirio, 1972), *C. capitata* (Sanders, 1962) and *A. suspense* (Greany and Szentesi, 1979), to different shapes of traps

Prokopy (1968a, 1973) demonstrated that more *R. pomonella* was captured on fluorescent yellow rectangles and enamel red spheres than other shapes of different colours. He hypothesized that flat surface of the rectangle represented leaf type stimulus, whereas, spheres constitute a fruit type stimulus.

Spheres were found more attractive to both female and male tephritid fruit flies than cubes, cylinders and rectangles of different surface (Prokopy, 1968b, Nakagawa *et al.*, 1978; Katsoyannos, 1989).

The most effective tactics developed for detecting the presence of adult blue berry maggot *R. mendax* include baited Pherocon AM yellow sticky boards (Prokopy and Coli, 1978).

Robacker (1992) opined that female Mexican fruitfly, *A. ludens* preferred large spheres over large rectangles and small rectangles over small spheres.

According to Cornelius *et al.,* (1999) greater number of female oriental fruit flies were attracted to yellow coloured spheres and rectangular blocks of equivalent surface.

Liburd *et al.* (2000) demonstrated that baited 9 cm diameter sphere was more effective in capturing blue berry maggots and yellow sticky boards captured significantly more fruit flies than sticky yellow Pherocon AM boards.

Smith *et al.* (2001) found that Pherotech *Rhagoletis* traps were more efficient than the conventional Pherocon AM traps for monitoring apple maggot *R. pomonella*.

In various trap designs, IIHR and open pan trap attracted significantly more number of *Bactrocera* spp. (Madhura and Viraktamath, 2003).

Among commercial traps, Fligh-T^{TM} attracted more *B. cucurbitae* (Coquillet) than modified Steiner trap as reported by Viraktamath and Rajitha (2005). In guava, *B. correcta* was attracted to spheres and cylinders while *B. zonata* to bottle traps. However, *B. dorsalis* did not show any preference to shape of the trap (Rajitha and Viraktamath, 2005a). But in

mango ecosystem *B. correcta* and *B. dorsalis* showed preference to spheres while *B. zonata* to spheres and bottles (Rajitha and Viraktamath, 2005b).

2.4 EVALUATION OF DIFFERENT PROTEIN FOOD BAITS IN ATTRACTING FEMALE FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

Earlier trapping systems for fruit flies relied on the use of baits made from protein and sugar (Gurney, 1925). Protein baits are complex mixtures derived from hydrolyzed proteins such as yeast, corn, soybean *etc.* They are attractive to both sexes of many fruit fly species (Steiner, 1952).

Oatman (1964) used household ammonia for the control of fruit flies. Reissig (1976) also reported the effectiveness of ammonium acetate.

According to Christenson and Foote (1960) female fruit flies need to feed on protein to mature sexually and for development of eggs.

Mazor *et al.* (2002) stressed the need of female attractive baits in monitoring and management of fruit flies as the female fruit flies are the dominant factors for multiplication.

Vijaysegaran (1985) reported that spraying of 0.2 per cent (ai) staley's protein insecticide bait No. 7 (PIB-7) + 0.2 per cent malathion was effective against melon fly.

According to Robacker *et al.* (1990) yeast hydrolyzate in green and yellow traps was more attractive to *A. ludens* . Wakabayashi and Cunningham (1991) found a four component mixture of ammonium bicarbonate, linoleic acid, putrescence and pyrroledine as highly attractive to melon fly *B. cucurbitae*.

A bait consisting of 10 per cent soybean protein hydrolyzate and 1.5 per cent mercapton was the most effective against Mediterranean fruit fly. With this treatment a high percentage of healthy fruits was maintained on the tree until harvest (Putruele *et al.*, 1993).

Traps baited with a two component blend of ammonium acetate and putrescence was effective in attracting Meditteranean fruit fly, *C. capitata* and Mexican fruit fly *A. ludens* (Heath *et al.*, 1995).

Robacker and Warfield (1993) reported that a blend of ammonium carbonate, putrescence and methyl amine, a mono substituted ammonia derivative was attractive to Mexican fruit fly, *A. ludens.*

Soundarrajan *et al.* (1996) reported that moist fish meal was the most effective bait in attracting melon fly, *B. cucurbitae*, which attracted 15 fruit flies/trap/day. Fermented palm juice was the next best treatment which attracted 7 fruit flies/trap/day.

International pheromone McPhail trap (IPMT) baited with three component food based synthetic attractant composed of ammonium acetate, putrescence, trimethyl amine, captured more female of the mediterranean fruit fly, *C. capitata* than males in citrus orchard (Gazit *et al.*, 1998).

Liburd *et al.* (1998) reported that Pherocon AM traps with ammonium acetate and protein hydrolysate captured significantly more *R. mendax* fruit flies.

Bakri *et al.* (1998) reported that cylindrical traps baited with two component synthetic lure of ammonium acetate and putrescence captured more females of Mediterranean fruit fly, *C. capitata*.

Epsky and Heath (1998) concluded that ammonium is used by several species of fruit flies to locate food and/or oviposition resources.

Jaggery was found to be the best food attractant for *B. tau* (Walker) followed by the mixture of ethyl methyl ketone + ammonium acetate, ethyl methyl ketone sugar, sugar + ethyl methyl ketone + ammonium acetate + water (Sood and Nath, 1998).

In a study conducted at Pusa, Vinod Kumar and Agarwal (1998) reported that mango pulp + mlathion attracted maximum *B. dorsalis*.

Agarwal and Kumar (1999a) found that treatment comprising methyl eugenol, mango pulp and malathion, resulted in maximum trapping of *B. zonata* (164.52 flies/trap/week) at Pusa. Combination of protein hydrolyzate, methyl eugenol and malathion attracted 151.74 fruitflies/trap/week.

Corneluis *et al.* (2000a, b) reported that liquid hydrolyzed proteinaceous bait (Nulure) attracted more female oriental fruit flies in guava orchard as compared to several ammonia based olfactory lures. Alyokhin *et al.* (2000) observed that protein odour significantly increased the number of oriental fruit flies captured by Ladd traps.

Papaya and guava based food baits attracted significantly more *Bactrocera* spp. at Bangalore (Madhura, 2001).

Boscan de Martinez *et al.* (2001) observed that nine per cent nulure + borax was effective in capturing *Anastrepha* spp. and *C. capitata*.

Sar *et al.* (2001) reported that protein bait spraying reduced amount of infestation by *B. fraunfeldi* (Schiner) in Carambola from 98 per cent to 1 per cent.

Sunandita and Gupta (2001) reported that bait mixtures consisting of boric acid and protein hydrolyzate caused 80 per cent mortality of *B. tau* at 10 and 12 per cent concentration of the toxicant.

Thomas *et al.* (2001) observed that open bottom plastic traps baited with two component synthetic lure (ammonium acetate and putrescine) caught more fruit flies than McPhail traps baited with Torula yeast.

Broughton and Francis De Lima (2002) observed that biolure outperformed the female targeted trapping system currently used for monitoring females of *C. capitata*.

Satpathy and Samarjit Rai (2002) reported that a bait containing pulp of over ripe banana (1 kg), carbofuron (10 g) + citric acid (1 g) was found to be the best in luring the melon fruit fly, *B. cucurbitae*, during its peak activity period.

Fabre *et al.* (2003) reported that solbait (protein hydrolyzate) was the most effective in capturing females of melon fly.

Katsoyannos and Papadopoulos (2004) reported that spheres baited with three component food attractant containing ammonium acetate, putrescence and trimethyl amine was most attractive to female *C. capitata*.

Among the various protein baits tested, yeast, soybean, fruit fly diet, protone and casein were more female selective, when total fruit flies were considered. Soybean + sugar + banana was the most superior protein bait with a fruit fly capture of 4.5/trap/week in guava, while casein + sugar + papaya attracted more female fruit flies with a mean capture of 4.33 in mango (Rajitha and Viraktamath, 2005c).

Fruit fly diet and casein based protein baits were promising against *B. dorsalis* in mango and guava orchard while *B. cucurbitae* was attracted to fruit fly diet, soybean, yeast in the same orchards as reported by Ravikumar (2005).

2.5 MONITORING THE INCIDENCE OF DIFFERENT SPECIES OF FRUIT FLIES USING METHYL EUGENOL TRAPS IN GUAVA AND MANGO ORCHARDS

2.5.1 Guava

Narayanan and Batra (1960) observed the peak incidence of fruit flies from July to September. However, Prasad and Bagle (1978) observed two peaks of *B. dorsalis* on guava from March to April and August to September in Bangalore. Similarly Belavadi (1979) also observed two peaks of *B. dorsalis* during the months of March-May and September-November under Dharwad conditions.

Liu *et al.* (1985) observed a decline in population of *B. dorsalis* from November to early May under Taiwan conditions. Vargas *et al.* (1989) observed the peak incidence from April and June and September to December in Hawaii.

In China, Chen *et al.* (1995) recorded a peak in *B. dorsalis* population from July to November. While, Hwang *et al.* (1997) observed the peak incidence from June to September. A decrease in the population was observed during winter.

Makhmoor and Singh (1998) recorded the peak population of *B. dorsalis* from the last fortnight of July to the first fortnight of August, with highest trap catches of 170.66 in the last week of July at Jammu.

Jalaluddin *et al.* (1999) recorded three peaks of *B. zonata* , *B. correcta* and *B. dorsalis* in Tamil Nadu. The first peak occurred during 2nd fortnight of June, 2nd peak during 2nd fortnight of July and 3rd peak during 2nd fortnight of August.

Gupta and Bhatia (2000) recorded the peak incidence of *B. dorsalis* and *B. zonata*, during the 37th and 39th standard weeks, with trap catches of 427.2 and 517.0 fruit flies respectively. Chaudhary and Jamal (2000) observed the peak activity of these fruit flies from August to October which coincided with the maturity period of guava.

Clarke *et al.* (2001) reported that *B. dorsalis* and *B. correcta* exhibited unimodal patterns of population abundance with peak incidence from June to September in guava.

Jalaluddin *et al.* (2001) observed the activity of fruit flies in guava, reaching a peak (223.5 flies/trap) during the 4th week of November.

In guava, *B. dorsalis* had one peak (45th standard week) at Dharwad and three peaks (43rd, 45th and 47th standard weeks) at Kumbapur (Viraktamath and Suresh Babu, 2004). Ravikumar (2005) observed three peaks of *B. dorsalis* during 27th, 45th and 48th standard weeks while *B. correcta* had the major peak during 27th standard week in 2004. *B. zonata* had two peaks during 11th and 18th standard weeks of 2005.

Rajitha and Viraktamath (2006a) observed the peak incidence of *B. dorsalis* during 30th standard week (27.16 fruit flies) and that of *B. correcta* during 30th and 45th standard weeks in 2003. *B. zonata* had three peaks, during 42nd standard week in 2003 and 11th and 12th standard weeks in 2004.

2.5.2 Mango

Bagle and Prasad (1983) recorded the peak activity of *B. dorsalis* during March, April, May and June with mean monthly trap catches of 1268, 270, 416 and 487 flies, respectively.

In southern Taiwan, Chiu and Chu (1986) observed the peak activity of *B. dorsalis* from June to September. An increase in the population was observed during April while a decline was noticed from December to March.

Mann (1996) observed the population of *B. dorsalis* throughout the year in methyl eugenol baited traps in mango orchard at Punjab. Low population was observed in winter months due to low temperature. Low catches were recorded in July.

Verghese and Sudhadevi (1998) observed a peak population of *B. dorsalis* in June followed by a minor peak in August, 1995. In 1996 the peak population was recorded in May and August coinciding with active breeding of fruit flies and another peak during September and November synchronizing with the guava season.

Sushilkumar *et al.* (1997) observed that the population of *B. dorsalis* peaked during 2nd fortnight of April (453 fruitflies/trap) and May (483 fruitflies/trap) and thereafter the population declined gradually. The peak activity of pest occurred from March to June coinciding with the fruiting period of crop.

Agarwal *et al.* (1999) reported that average number of *B. dorsalis* and *B. zonata* trapped in Bihar in April and August, 1997 was 39.94 and 134.92 fruit flies per trap per week respectively.

Agarwal and Kumar (1999b) studied the population dynamics of *B. Zonata* from April to August 1997 in north Bihar. The peak population (357.0 fruit flies per trap) was observed during 3rd week of June while minimum population (14.3 flies per trap) during last week of August.

Anjum *et al.* (2000) observed peak population of *B. zonata* in the first week of July. The population of *B. zonata* was higher than of *B. dorsalis*.

Gupta and Bhatia (2000) reported that the maximum catches of *B. dorsalis* and *B. zonata* as 98.6 to 62.6 fruit flies during 30th and 27th standard weeks in 1992 and 1993 respectively in mango orchard at Himachal Pradesh.

Seewooruthun *et al.* (2001) observed the peak activity of *B. dorsalis* during June, followed by two small peaks in July and September. The peak activity of *B. zonata* was observed during April-June.

Madhura (2001) studied the seasonal activity of fruit flies during 1998-2000. In 1998 peak population was observed during 3rd week of May (315.14 fruit flies/week). During 1999, two peaks were observed, during 3rd week of May (282.29 fruit flies/week) and 3rd week of June (182.43 flies/trap/week). In 2000 increase in population commenced from 4th week of April and peak population was observed during 3rd week of May.

Sarada *et al.* (2001b) reported the seasonal incidence and population fluctuation of fruit flies in Chittor district of Andhra Pradesh from February to July, 2000. The population gradually increased from the first week of February, 2000 (34 fruit flies) to 5th week of June, 2000 (235.0 fruit flies). The peak population was observed from May to June coinciding with fruit maturity period.

B. dorsalis was first observed in April with 3 per cent infestation which gradually increased in May (8.2%), June (9.8%) and slightly declined in July (8.3%) in Mango orchard at Karpur (Dwivedi *et al.*, 2003).

Sureshbabu and Viraktamath (2003) reported one peak of *B. zonata* (21st week), three peaks of *B. correcta* (19th, 23rd and 47th standard week) and three peaks of *B. dorsalis* (21st, 23rd and 46th week) at Dharwad. However, Rajitha and Viraktamath (2006b) observed one peak of *B. dorsalis* (30th standard week) four peaks each of *B. correcta* (45th, 52nd, 1st and 3rd standard weeks) and *B. zonata* (42nd, 45th, 8th and 13th standard weeks) at Dharwad.

Shekharappa *et al.* (1998), Madhura (2001) and Suresh Babu and Viraktamath (2003) opined that the population fluctuation of fruit flies is dependent on the availability of the host crops.

Ravikumar (2005) observed the peak incidence of *B. correcta* during first fortnight of July. *B. dorsalis* had two major peaks during 1st week of July (27th standard week) and 3rd week of November (47th standard week) (132.67 furit flies/trap week) in 2004. *B. zonata* had the major peak of 37.67 fruit flies/week during last week of May (21st standard week).

2.6 INFLUENCE OF WEATHER PARAMETERS ON TRAP CATCHES IN GUAVA AND MANGO ORCHARDS

2.6.1 Guava

Shukla and Prasad (1985) reported that the peak trap catches of *B. dorsalis* had significant correlation with temperature and relative humidity. They noticed a negative correlation between weekly rainfall and *B. dorsalis* captures and a negative correlation with average number of dry light hours. A low negative correlation was observed with weekly wind velocity.

Makhmoor and Singh (1998) reported that temperature had a negative correlation while relative humidity and rainfall had a positive correlation with the population of *B. dorsalis*.

A significant positive correlation was observed between trap catches of *B. dorsalis* and *B. zonata* with maximum and minimum temperature (Gupta and Bhatia, 2000).

Jalaluddin *et al.* (2001) observed a significant correlation between the population of *B. correcta* and mean maximum temperature, minimum temperature, day degrees, morning relative humidity and rainfall and a low negative correlation with weekly mean sunshine hours.

Sarada *et al.* (2001b) found that the fruit fly incidence had significant positive correlation with maximum temperature and non-significant and positive correlation with minimum temperature at Tirupati.

At Dharwad trap captures of *B. zonata* and *B. correcta* had significant positive correlation with maximum temperature and a highly significant negative correlation with morning relative humidity. At Kumbapur, both the species had positive correlation with maximum temperature and relative humidity (Viraktamath and Suresh Babu, 2004). According to Rajitha and Viraktamath (2006a) *B. dorsalis* had significant positive correlation with minimum temperature and morning and afternoon relative humidity. It had significant negative correlation with maximum temperature. Trap captures of *B. zonata* showed a highly significant positive correlation with maximum temperature.

2.6.2 Mango

Bagle and Prasad (1983) reported a significant positive correlation between weekly trap catches of *B. dorsalis* and maximum temperature and a negative correlation with relative humidity, rainfall and wind velocity. Similarly, Agarwal *et al.* (1995) also observed a significant positive correlation between trap catches of *B. dorsalis* and maximum and minimum temperature.

The population of *B. correcta* was positively correlated with maximum and minimum temperature, whereas, rainfall, sunshine hours and relative humidity had no significant effect on population variation (Sushilkumar *et al.*, 1997).

Verghese and Sudhadevi (1998) reported a significant positive correlation of the trap catches of *B. dorsalis* with minimum temperature and wind speed.

Agarwal and Kumar (1999b) obtained a positive correlation between trap catches of *B. zonata* and maximum temperature, minimum temperature and rainfall and a negative correlation with relative humidity.

According to Madhura (2001), the population of fruit flies showed a non-significant correlation with maximum temperature during 1998 and a significant negative correlation during 1999, and a significant positive correlation during 2000. Reative humidity had a negative correlation during 1998 and 2000, and a positive correlation during 1999.

According to Sarada *et al.* (2001b) the fruit fly population had positive correlation with minimum temperature and rainfall, whereas with relative humidity it had negative correlation. The correlation was positive and non-significant with maximum temperature.

B. zonata and *B. correcta* had a significant positive correlation with minimum temperature at Dharwad, while at Kumbapur the species had positive correlation with maximum and minimum temperature (Sureshbabu and Viraktamath, 2003).

There was a highly significant positive correlation between trap catches of *B. dorsalis* and minimum temperature, morning and afternoon relative humidity. *B. correcta* had a significant positive correlation with minimum temperature while *B. zonata* had a significant positive correlation with maximum temperature (Rajitha and Viraktamath, 2006b).

III. MATERIAL AND METHODS

Various materials used and methods adopted for the studies on evaluation on the quantity and frequency of charging with methyl eugenol, efficacy of various coloured traps, different shapes of the traps and evaluation of protein food baits and monitoring of fruit flies are presented in this chapter.

3.1 TO EVALUATE ON THE QUANTITY AND FREQUENCY OF CHARGING OF THE TRAPS WITH METHYL EUGENOL IN GUAVA AND MANGO ORCHARDS

3.1.1 Evaluation on the quantity of charging of traps with methyl eugenol

This experiment was conducted during first fortnight of November, 2005 in guava and first fortnight of April, 2006 in mango. There were eight treatments which included charging the traps with different quantity of methyl eugenol and a trap prepared as per the recommended package of practices (POP trap). The POP trap consisted of a transparent bottle (with top portion cut) containing 100 ml of 0.1 per cent methyl eugenol solution + 1 ml dichlorovos (Anonymous, 2004b). This POP trap served as a control trap in the experiment.

The experiment was conducted in a farmer's commercial orchard of guava (6 acres) and mango (8 acres) at Mummigatti near Dharwad.

The methyl eugenol traps used were transparent 1000 ml bottle traps. Each bottle trap had four holes of 20 mm diameter on four sides and a cotton wad charged with methyl eugenol + dichlorovos and placed in a loop of iron wire. The treatments were replicated thrice. The details of treatments were as follows.

T_1 – Trap charged with 0.1 ml methyl eugenol + 1 ml dichlorovos
T_2 – Trap charged with 0.2 ml methyl eugenol + 1 ml dichlorovos
T_3 – Trap charged with 0.3 ml methyl eugenol + 1 ml dichlorovos
T_4 – Trap charged with 0.4 ml methyl eugenol + 1 ml dichlorovos
T_5 – Trap charged with 0.5 ml methyl eugenol + 1 ml dichlorovos
T_6 – Trap charged with 0.75 ml methyl eugenol + 1 ml dichlorovos
T_7 – Trap charged with 1 ml methyl eugenol + 1 ml dichlorovos
T_8 – POP trap (control)

The fruit flies from both orchards were collected separately at weekly intervals for one month and identified to the species level by using keys given by Ramani (1997). The number of fruit flies trapped in each treatment in guava and mango was pooled species wise and means of each species of fruit fly per trap per week was calculated. Similarly total fruit flies irrespective of species in guava and mango were pooled separately. The data were subjected to RBD analysis after ($\sqrt{x}+0.5$) transformation.

3.1.2 Evaluation on the frequency of charging of traps with methyl eugenol

This experiment was conducted during first fortnight of December in guava and second fortnight of May in mango based on the best treatment obtained from the experiment 3.1.1.

Bottle traps of 1000 ml were used in this study. Each trap was charged with $\overline{0.2}$ ml of methyl eugenol as per the best treatment from the studies in the experiment 1. There were five treatments replicated four times. The details of treatments were as follows.

T_1 – Charging of traps at 1 week interval with methyl eugenol
T_2 – Charging of traps at 2 weeks interval with methyl eugenol
T_3 – Charging of traps at 3 weeks interval with methyl eugenol
T_4 – Charging of traps at 4 weeks interval with methyl eugenol

Plate 1. Trap prepared as per package of practices (POP trap)

T_5 – POP trap (control)

Similar procedure as given under 3.1.1 was followed for recording observations. The efficacy of each treatment was analysed by RBD analysis after $\sqrt{x+0.5}$ transformation.

3.2 TO EVALUATE ON THE EFFICACY OF DIFFERENT COLOURED TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

The study was carried out in farmers orchards of guava (10 acres) and mango orchards (8 acres) at Mummigatti, Dharwad, during the first fortnight of November 2005 in guava and first fortnight of April 2006 in mango. Eight traps which differed in colour were set up in each of guava and mango orchard separately. Cylinder traps of 500 ml size were used for the study. Each trap had four holes of 20 mm in size on four sides and a cotton wad charged with 0.4 ml methyl eugenol and 1 ml of dichlorovos, placed inside the trap in a loop made of iron wire. Each trap was serviced with these chemicals at monthly and fortnightly intervals respectively. Care was taken to maintain a distance of 50 m between two traps to avoid trap interference and the position of traps was randomly changed at fortnight intervals to nullify the effect of position of trap in attracting fruit flies.

Each treatment was replicated thrice and the details of the treatments were as follows.

T_1 – Transparent cylinder trap
T_2 – Red cylinder trap
T_3 – Yellow cylinder trap
T_4 – Green cylinder trap
T_5 – Orange cylinder trap
T_6 – Black cylinder trap
T_7 – Blue cylinder trap
T_8 – White cylinder trap

The fruit flies from both the orchards were collected separately at weekly intervals for two months and identified to the species level. The number of fruit flies trapped in each treatment in guava and mango was pooled species wise separately and means of each species of fruit fly/trap/week was calculated. Trap catches of total fruit flies irrespective of species was also pooled. The data were subjected to RBD analysis after $(\sqrt{x+0.5})$ transformation.

3.3 TO EVALUATE ON THE EFFICACY OF DIFFERENT SHAPES OF TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

This experiment was conducted during second fortnight of November in guava and first fortnight of April in mango. Five traps with different shapes like bottle, cylinder, sphere traps and open traps, along with one commercial melon fruit fly trap namely Del-Ta trap (supplied by the Pest Control (India) Bangalore) were evaluated in comparison with other traps in a commercial orchard of guava and mango separately at Mummigatti. These traps were prepared as per the procedure given under 3.2

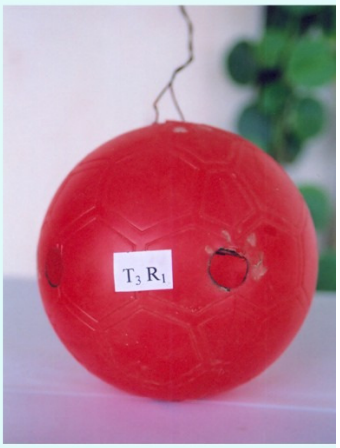
Each treatment was replicated four times. The position of the traps was changed at weekly intervals to avoid the position effect on the traps. The details of treatments were as follows.

T_1 – Bottles
T_2 – Cylinders
T_3 – Spheres
T_4 – Del-Ta smeared with grease
T_5 – Open trap smeared with grease

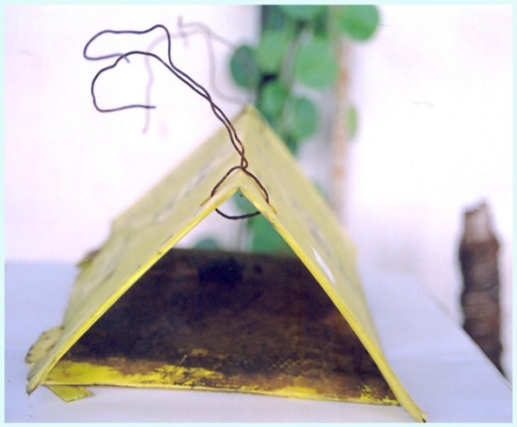
Plate 2. Different colours of traps evaluated

Bottle

Cylinder



Sphere



Open trap

Plate 3. Different shapes of traps evaluated

Procedure as given under 3.2 was followed for recording observations. The efficacy of each treatment was analysed by RBD analysis after ($\sqrt{x}+0.5$) transformation.

3.4 TO EVALUATE DIFFERENT FOOD BAITS IN ATTRACTING FEMALE FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

This experiment was conducted during peak fruiting season of guava (1st week of October to 4th week of November) and mango (six weeks during April-May) in a commercial orchards at Mummigatti.

Different proteins tested were soybean yeast, casein, fruit fly diet, fishmeal and proteinex. The first four proteins were obtained from Hi Media Laboratories Private Limited, Mumbai, India and the last two were obtained from the local market. Protein food baits were prepared by using guava and mango pulp as base in guava and mango orchards, respectively. The experiment was laid out in a randomized block design with 14 treatments and two replications in mango and guava separately.

The details of treatments in guava were as follows.

T_1 – Soybean + sugar + guava pulp (1:1:1) + 5% ammonium acetate
T_2 – Yeast + sugar + guava pulp (1:1:1) + 5% ammonium acetate
T_3 – Casein + sugar + guava pulp (1:1:1) + 5% ammonium acetate
T_4 – Fruitfly diet + sugar + guava pulp (1:1:1) + 5% ammonium acetate
T_5 – Fishmeal + 5% ammonium acetate
T_6 – Guava pulp + sugar (1:1) + 5% ammonium acetate
T_7 – Proteinex + 5% ammonium acetate
T_8 – Soybean + sugar + guava pulp (1:1:1) + 5% acetic acid
T_9 – Yeast + sugar + guava pulp (1:1:1) + 5% acetic acid
T_{10} – Casein + sugar + guava pulp (1:1:1) + 5% acetic acid
T_{11} – Fruitfly diet + sugar + guava pulp (1:1:1) + 5% acetic acid
T_{12} – Fishmeal + 5% acetic acid
T_{13} – Guava pulp + sugar (1:1) + 5% acetic acid
T_{14} – Proteinex + 5% acetic acid

The details of treatments in mango were as follows.

T_1 – Soybean + sugar + mango pulp (1:1:1) + 5% ammonium acetate
T_2 – Yeast + sugar + mango pulp (1:1:1) + 5% ammonium acetate
T_3 – Casein + sugar + mango pulp (1:1:1) + 5% ammonium acetate
T_4 – Fruitfly diet + sugar + mango pulp (1:1:1) + 5% ammonium acetate
T_5 – Fishmeal + 5% ammonium acetate
T_6 – Mango pulp + sugar (1:1) + 5% ammonium acetate
T_7 – Proteinex + 5% ammonium acetate
T_8 – Soybean + sugar + mango pulp (1:1:1) + 5% acetic acetate
T_9 – Yeast + sugar + mango pulp (1:1:1) + 5% acetic acid
T_{10} – Casein + sugar + mango pulp (1:1:1) + 5% acetic acid
T_{11} – Fruitfly diet+ sugar + mango pulp (1:1:1) + 5% acetic acid
T_{12} – Fishmeal + 5% acetic acid
T_{13} – Mango pulp + sugar (1:1) + 5% acetic acid
T_{14} – Proteinex + 5% acetic acid

The food baits were placed in small plastic cups separately and were kept inside the traps. The bait was always kept in semi liquid state by adding 10-15 ml water at regular intervals. Weekly observations on the number of fruit flies trapped in each trap were recorded, sexed and counted. Efficacy of each combination of food lure was evaluated by RBD analysis after $\sqrt{x}+0.5$ transformation of data.

Plate 4. Trap with protein food bait (proteinex)

Plate 4. Trap with protein food bait (proteinex)

Plate 5. Female fruit flies trapped in protein food bait (fruit fly diet)

Plate 5. Female fruit files trapped in protein food bait (fruit fly diet)

3.5 TO MONITOR THE INCIDENCE OF DIFFERENT SPECIES OF FRUIT FLIES USING METHYL EUGENOL TRAPS IN GUAVA AND MANGO ORCHARDS

The experiment was conducted for one calendar year from July, 2005 to May 2006. Eight bottle traps were set up separately in guava (2.5 acres) and mango (5.5 acres) orchards, of the University of Agricultural Sciences, Dharwad. Care was taken to maintain a distance of 50 m between the traps to avoid trap interference effect. These traps were charged with 0.4 ml of methyl eugenol and 1 ml of dichlorovos at monthly and fortnightly intervals respectively. The fruit flies were collected at weekly intervals and identified to species level and recorded.

3.6 TO STUDY THE INFLUENCE OF WEATHER PARAMETERS ON TRAP CATCHES IN GUAVA AND MANGO ORCHARDS

The influence of weather factors on trap catches was studied by using the data collected under monitoring studies.

Meteorological parameters like maximum temperature, minimum temperature morning and afternoon relative humidity and rainfall data were collected from Agromet Advisory Unit of the University of Agricultural Sciences, Dharwad.

Correlations were made between trap catches and mean weather parameters like maximum temperature, minimum temperature, morning and afternoon relative humidity and rainfall for every standard week.

Plate 6. A view of guava orchard

Plate 6. A view of guava orchard

Plate 7. A view of mango orchard

Plate 7. A view of mango orchard

IV. EXPERIMENTAL RESULTS

Results of the studies on evaluation of different quantities of methyl eugenol and frequency of charging, efficacy of different colours and shapes of traps, evaluation of protein food baits against female fruit flies, monitoring and relationship between trap catches and weather parameters are presented in this chapter.

4.1 EVALUATION ON THE QUANTITY AND FREQUENCY OF CHARGING OF THE TRAPS WITH METHYL EUGENOL IN GUAVA AND MANGO ORCHARDS

4.1.1 Evaluation of different quantities of methyl eugenol in trapping fruit flies in guava and mango orchards

Guava

Evaluation against *B. correcta*

The trap charged with 0.1 ml methyl eugenol captured highest number of 31.17 fruit flies/trap/week which was at par with the trap charged with 0.2 ml methyl eugenol with the capture of 25.58 fruit flies/trap/week (Table 1). The next higher catches were recorded in the traps charged with 0.3 and 0.4 ml methyl eugenol (21.17 and 22.67 fruit flies/trap/week) followed by the traps charged with 0.5, 0.75 and 1.00 ml methyl eugenol (12.08, 10.56 and 10.26 fruit flies/trap/week, respectively). The POP trap captured significantly lowest number of fruit flies (0.33 fruit flies/trap/week).

Evaluation against *B. dorsalis*

Highest number of *B. dorsalis* (10.25 fruit flies/trap/week) was captured in the trap charged with 0.1 ml methyl eugenol (Table 1). Traps charged with 0.2 and 0.75 ml methyl eugenol attracted next higher number of fruit flies (7.25 and 7.83 fruit flies/trap/week, respectively) followed by the traps charged with 0.3, 0.4 and 1 ml methyl eugenol which were however at par with each other. Significantly lowest number of 0.25 fruit flies/trap/week were captured in the POP trap.

Evaluation against pooled fruit flies

When the total fruit flies irrespective of the species were considered, traps charged with 0.1 ml methyl eugenol attracted significantly highest number of fruit flies with mean trap catches of 41.42 fruit flies/trap/week followed by traps charged with 0.2 ml methyl eugenol (32.83 fruits flies/trap/week) (Table 1). The next best trap catches were recorded in the traps charged with 0.4 ml and 0.3 ml methyl eugenol (27.00 and 25.53 fruit flies/trap/week, respectively). The POP trap recorded least number of fruits flies (0.58 fruit flies/trap/week).

Mango

Evaluation against *B. correcta*

Highest number of *B. correcta* (6.92 fruit flies/trap/week) was captured in the trap charged with 0.2 ml methyl eugenol (Table 2). The next best equally effective treatments were charging with 1.0 ml, 0.4 ml and 0.3 ml methyl eugenol (4.08, 4.00 and 3.83 fruit flies/trap/week respectively) followed by the traps charged with 0.1 ml and 0.75 ml methyl eugenol which were at par with each other (2.83 and 2.58 fruit flies/trap/week, respectively). The lowest number of 0.55 fruit flies/trap/week were captured in the POP trap.

Evaluation against *B. dorsalis*

Table 1. Evaluation of different quantities of methyl eugenol in trapping fruit flies in guava orchard

Treatments \ Species	Mean fruit flies/trap/week		
	B. correcta	*B. dorsalis*	Total fruit flies
0.1 ml methyl eugenol	31.17[a]	10.25[a]	41.42[a]
	(5.63)	(3.28)	(6.47)
0.2 ml methyl eugenol	25.58[ab]	7.25[b]	32.83[b]
	(5.10)	(2.78)	(5.77)
0.3 ml methyl eugenol	21.17[b]	4.17[c]	25.53[c]
	(4.65)	(2.16)	(5.10)
0.4 ml methyl eugenol	22.67[b]	4.33[c]	27.00[c]
	(4.64)	(2.20)	(5.24)
0.5 ml methyl eugenol	12.08[c]	2.25[d]	14.33[e]
	(3.54)	(1.66)	(3.85)
0.75 ml methyl eugenol	10.56[c]	7.83[b]	18.39[d]
	(3.30)	(2.88)	(4.34)
1.00 ml methyl eugenol	10.26[c]	4.17[c]	14.43[e]
	(3.75)	(1.60)	(3.83)
POP trap	0.33[d]	0.25[e]	0.58[f]
	(0.91)	(0.87)	(1.03)
S.Em.±	0.205	0.073	0.150
CD at 5%	0.624	0.221	0.456

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Table 2. Evaluation of different quantities of methyl eugenol in trapping fruit flies in mango orchard

Treatments \ Species	Mean fruit flies/trap/week			
	B. correcta	*B. dorsalis*	*B. zonata*	Total fruit flies
0.1 ml methyl eugenol	2.83^{c}	1.25^{c}	0.92^{bc}	5.00^{c}
	(1.83)	(1.32)	(1.19)	(2.34)
0.2 ml methyl eugenol	6.92^{a}	2.92^{a}	2.75^{a}	12.59^{a}
	(2.72)	(1.85)	(1.80)	(3.60)
0.3 ml methyl eugenol	3.83^{b}	0.67^{d}	0.33^{e}	4.83^{c}
	(2.08)	(1.08)	(0.91)	(2.30)
0.4 ml methyl eugenol	4.00^{b}	2.25^{b}	1.00^{bc}	7.25^{b}
	(2.12)	(1.66)	(1.22)	(2.78)
0.5 ml methyl eugenol	1.50^{d}	0.75^{d}	0.50^{de}	2.75^{d}
	(1.41)	(1.11)	(1.00)	(1.80)
0.75 ml methyl eugenol	2.58^{c}	0.97^{cd}	0.58^{de}	4.13^{c}
	(1.75)	(1.21)	(1.04)	(2.15)
1.00 ml methyl eugenol	4.08^{b}	2.42^{ab}	1.17^{b}	7.67^{b}
	(2.14)	(1.71)	(1.29)	(2.85)
POP trap	0.55^{e}	0.33^{e}	0.67^{cd}	1.55^{e}
	(1.02)	(0.91)	(1.08)	(1.43)
S.Em.±	0.075	0.048	0.048	0.098
CD at 5%	0.228	0.146	0.146	0.298

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

The trap charged with 0.2 ml methyl eugenol captured highest number of 2.92 fruit flies/trap/week which was at par with the trap charged with 1 ml methyl eugenol (2.42 fruit flies/trap/week) followed by trap charged with 0.4 ml methyl eugenol (Table 2). The next higher number of catches was recorded with 0.1 ml methyl eugenol followed by the traps charged with 0.75 ml, 0.5 ml and 0.3 ml methyl eugenol which were however at par with each other (0.97, 0.75, 0.67 fruit flies/trap/week respectively). The POP trap captured significantly lowest number of fruit flies (0.33 fruit flies/trap/week).

Evaluation against *B. zonata*

Significantly highest number of trap catches was recorded in the trap charged with 0.2 ml methyl eugenol (2.75 fruit flies/trap/week) followed by trap charged with 1.0 ml methyl eugenol (1.17 fruit flies/trap/week) (Table 2). The next higher number of catches was recorded in the trap charged with 0.4 and 0.1 ml methyl eugenol (1.00 and 0.92 fruit flies/trap/week, respectively) followed by the POP trap (0.6 fruit flies/trap/week) which was at par with trap charged with 0.75 ml and 0.5 ml (0.58 and 0.50 fruit flies/trap/week respectively). The lowest number of trap catches was recorded in the trap charged with 0.3 ml methyl eugenol.

Evaluation against pooled fruit flies

When the fruit flies, irrespective of the species were considered, traps charged with 0.2 ml methyl eugenol attracted significantly more fruit flies with mean trap catches of 12.59 fruit flies/trap/week followed by the trap charged with 1 ml (7.67 fruit flies/trap/week) which was at par with trap charged with 0.4 ml (7.25 fruit flies/trap/week) (Table 2). The POP trap attracted significantly lowest number of fruit flies (1.55 fruit flies/trap/week).

4.1.2 Evaluation on the frequency of charging of methyl eugenol in trapping fruit flies in guava and mango orchards

Guava

Evaluation against *B. correcta*

Higher number of 21.03 fruit flies/trap/week were captured in the trap that was charged at two weeks interval (Table 3). However, the fruit fly captures in the traps that were charged at one, three and four weeks interval were also at par and varied from 18.03 to 19.40 fruit flies/trap/week. The POP trap attracted significantly lowest number of fruit flies (1.63 fruit flies/trap/week).

Evaluation against *B. dorsalis*

Significantly highest number of 1.63 fruit flies were captured in the trap that was charged at one week interval (Table 3). The trap which was charged at two weeks interval captured the next higher number of fruit flies (0.94 fruit flies/trap/week) followed by the traps that were charged at three and four weeks interval (0.72 and 0.66 fruit flies/trap/week, respectively) which were however on par with each other. The POP trap was least effective capturing the lowest number of fruit flies (0.19 fruit flies/trap/week).

Evaluation against pooled fruit flies

When the fruit flies, irrespective of the species were considered traps charged at one, two, three and four weeks intervals attracted higher number of fruit flies (19.02 to 21.94 fruit flies/trap/week) (Table 3). The lowest number of catches were recorded in the POP trap (1.82 fruit flies/trap/week).

Table 3. Evaluation on the frequency of charging of methyl eugenol in trapping fruit flies in guava orchard

Treatments \ Species	Mean fruit flies/trap/week		
	B. correcta	*B. dorsalis*	Total fruit flies
Charging* at 1 week interval	18.03[a]	1.63[a]	19.66[a]
	(4.31)	(1.47)	(4.48)
Charging* at 2 weeks interval	21.03[a]	0.94[b]	21.94[a]
	(4.74)	(1.20)	(4.73)
Charging* at 3 weeks interval	18.3[a]	0.72[c]	19.02[a]
	(4.34)	(1.10)	(4.41)
Charging* at 4 weeks interval	19.4[a]	0.66[c]	20.06[a]
	(4.46)	(1.08)	(4.53)
POP trap	1.63[b]	0.19[d]	1.82[b]
	(1.46)	(0.83)	(1.52)
S.Em.±	0.163	0.022	0.137
CD at 5%	0.520	0.068	0.424

* Charging with methyl eugenol @ 0.1 ml

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Mango

Evaluation against *B. correcta*

The traps charged at one, two and three weeks intervals captured significantly higher number of fruit flies (3.44 to 3.56 fruit flies/trap/week) (Table 4). The trap charged at four week interval captured next higher number of fruit flies (2.31 fruit flies/trap/week) followed by POP trap (0.31 fruit flies/trap/week).

Evaluation against *B. dorsalis*

The trap charged at three weeks intervals attracted significantly highest number of fruit flies (1.06 fruit flies/trap/week) which was however at par with the trap charged at one, two and four weeks intervals (0.81, 1.00 and 0.94 fruit flies/trap/week) (Table 4). The POP trap captured lowest number of fruit flies (0.31 fruit flies/trap/week).

Evaluation against *B. zonata*

Significantly highest number of 4.06 fruit flies were captured in the trap that was charged at two weeks interval which was at par with the trap charged at one and four weeks interval (3.75 and 3.5 fruit flies/trap/week) (Table 4). The POP trap captured lowest number of fruit flies (0.5 fruit flies/trap/week).

Evaluation against pooled fruit flies

Traps charged at one, two and three weeks interval were found significantly superior in attracting higher number of fruit flies (8.06, 8.5 and 8.06 fruit flies/trap/week respectively) (Table 4). The traps charged at four weeks interval captured the next higher number of fruit flies (6.75 fruit flies/trap/week) followed by POP trap (1.12 fruit flies/trap/week).

4.2 EVALUATION ON THE EFFICACY OF DIFFERENT COLOURED TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

4.2.1 Evaluation on the efficacy of different coloured traps in capturing fruit flies in guava

Evaluation against *B. correcta*

Yellow coloured trap captured significantly highest number of *B. correcta* (70.45 fruit flies/trap/week) followed by transparent, orange, green, black and white coloured traps with catches of 55.50, 41.46, 36.92, 34.00 and 28.87 fruit flies/trap/week, respectively (Table 5). Red and blue traps attracted significantly lowest number of *B. correcta* with catches of 23.17 and 24.09 fruit flies/trap/week, respectively which however did not vary statistically.

Evaluation against *B. dorsalis*

Response of *B. dorsalis* to various coloured traps varied significantly and is presented in table 5. Green and orange coloured traps were at par with each other and attracted significantly higher number of fruit flies (3.79 and 3.75 fruit flies/trap/week, respectively). The next higher number of fruit flies were captured in blue coloured trap (2.71 fruit flies/trap/week) followed by the transparent and black coloured traps (1.95 and 1.92 fruit flies, respectively) which however were at par with each other. The captures in red coloured trap was significantly low (1.00 fruit flies/trap/week) which was also at par with the catches in yellow (1.46 fruit flies/trap/week) and white (1.37 fruit flies/trap/week) coloured traps.

Evaluation against pooled fruit flies

Table 4. Evaluation on the frequency of charging of methyl eugenol in trapping fruit flies in mango orchard

Species / Treatments	Mean fruit flies/trap/week			
	B. correcta	*B. dorsalis*	*B. zonata*	Total fruit flies
Charging* at 1 week interval	3.50[a] (2.00)	0.81[a] (1.15)	3.75[ab] (2.06)	8.06[a] (2.92)
Charging* at 2 weeks interval	3.44[a] (1.98)	1.00[a] (1.22)	4.06[a] (2.14)	8.50[a] (3.00)
Charging* at 3 weeks interval	3.56[a] (2.00)	1.06[a] (1.25)	3.44[b] (1.98)	8.06[a] (2.92)
Charging* at 4 weeks interval	2.31[b] (1.67)	0.94[a] (1.20)	3.50[ab] (2.00)	6.75[b] (2.69)
POP trap	0.31[c] (0.90)	0.31[b] (0.90)	0.50[c] (1.00)	1.12[c] (1.27)
S.Em±	0.054	0.031	0.044	0.057
CD at 5%	0.168	0.097	0.137	0.175

* Charging with methyl eugenol @ 0.2 ml

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Table 5. Evaluation on the efficacy of different coloured traps in capturing fruit flies in guava orchard

Treatments \ Species	Mean fruit flies/trap/week		
	B. correcta	*B. dorsalis*	Total fruit flies
Transparent trap	55.50^{b}	1.95^{c}	57.45^{b}
	(7.48)	(1.56)	(7.61)
Red trap	23.17^{f}	1.00^{d}	24.17^{f}
	(4.86)	(1.22)	(4.96)
Yellow trap	70.45^{a}	1.46^{cd}	71.91^{a}
	(8.42)	(1.40)	(8.50)
Green trap	36.92^{cd}	3.79^{a}	40.71^{cd}
	(6.12)	(2.07)	(6.41)
Orange trap	41.46^{c}	3.75^{a}	45.21^{c}
	(6.48)	(2.06)	(6.76)
Black trap	34.00^{d}	1.92^{c}	35.92^{d}
	(5.86)	(1.55)	(6.03)
Blue trap	24.09^{f}	2.71^{b}	26.80^{ef}
	(4.96)	(1.78)	(5.22)
White trap	28.87^{e}	1.37^{cd}	30.24^{e}
	(5.42)	(1.36)	(5.54)
S.Em.±	0.139	0.065	0.144
CD at 5%	0.421	0.199	0.439

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

When the total fruit flies were considered irrespective of the species, yellow traps attracted significantly highest number of fruit flies (71.91 fruit flies/trap/week) (Table 5). The next higher number of fruit flies were trapped in the transparent trap (57.45 fruit flies/trap/week) followed by orange and green traps. However, blue and red traps were least effective attracting significantly lower number of fruit flies (26.80 and 24.17 fruit flies/trap/week, respectively).

4.2.2 Evaluation on the efficacy of different coloured traps in capturing fruit flies in mango orchards

Evaluation against *B. correcta*

Significantly highest number of *B. correcta* was captured in transparent trap (5.13 fruit flies/trap/week) (Table 6). Yellow, black, red and green traps captured the next higher number of fruit flies and were at par with each other (3.67, 3.38, 3.04, 3.00 fruit flies/trap/week respectively). Blue and white traps attracted significantly lowest number of *B. correcta* with catches of 2.09 and 2.04 fruit flies/trap/week which were however at par with each other.

Evaluation against *B. dorsalis*

Black coloured trap captured significantly highest number of *B. dorsalis* (3.88 fruit flies/trap/week) (Table 6). The next higher capture was observed in orange, transparent and white colour traps which were at par with each other (1.17, 1.25, 1.08 fruit flies/trap/week respectively). Green and yellow were equally effective which attracted 0.75 and 0.79 fruit flies/trap/week followed by blue and red (0.67 and 0.54 fruit flies/trap/week).

Evaluation against *B. zonata*

Red colour trap attracted significantly highest number of fruit flies (3.75 fruit flies/trap/week) followed by black (1.42 fruit flies/trap/week) which was at par with transparent, orange, green, yellow and blue traps (0.96 to 1.38 fruit flies/trap/week) (Table 6). The least number of fruit flies was attracted to white colour (0.88 fruits flies/trap/week).

Evaluation against pooled fruit flies

When the fruit flies irrespective of the species were considered black coloured traps attracted significantly more number of fruit flies with mean trap catches of 8.68 fruit flies/trap/week followed by transparent and red colour traps (7.76 and 7.33 fruit flies/trap/week) (Table 6). Yellow, green and orange coloured traps were the next best catches (5.08 to 5.55 fruit flies/trap/week). The lowest number of trap catches were recorded in blue and white traps (3.72 and 4.00 fruit flies/trap/week respectively).

4.3 EVALUATION ON THE EFFICACY OF DIFFERENT SHAPES OF TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

4.3.1 Evaluation on the efficacy of different shapes of traps in capturing fruit flies in guava orchard

Evaluation against *B. correcta*

The captures of *B. correcta* in different shapes of traps varied significantly and the data is presented in Table 7. Bottle and cylinder traps were equally effective and captured significantly higher number of 32.09 and 31.25 fruit flies/trap/week, respectively. Spheres and Delta traps were at par with each other and captured next higher number of 22.78 and 25.09 fruit flies/trap/week, respectively. Significantly lowest number of 10.56 fruit flies was captured in the open trap.

Table 6. Evaluation on the efficacy of different coloured traps in capturing fruit flies in mango orchard

Treatments \ Species	Mean fruit flies/trap/week			
	B. correcta	*B. dorsalis*	*B. zonata*	Total fruit flies
Transparent trap	5.13[a]	1.25[b]	1.38[b]	7.76[b]
	(2.37)	(1.32)	(1.37)	(2.87)
Red trap	3.04[bc]	0.54[d]	3.75[a]	7.33[b]
	(1.88)	(1.02)	(2.06)	(2.79)
Yellow trap	3.67[b]	0.75[cd]	1.13[bc]	5.55[c]
	(2.04)	(1.12)	(1.28)	(2.45)
Green trap	3.00[bc]	0.79[cd]	1.29[bc]	5.08[c]
	(1.87)	(1.14)	(1.34)	(2.36)
Orange trap	2.83[c]	1.17[b]	1.30[bc]	5.30[c]
	(1.83)	(1.29)	(1.34)	(2.40)
Black trap	3.38[bc]	3.88[a]	1.42[b]	8.68[a]
	(1.97)	(2.09)	(1.38)	(3.02)
Blue trap	2.09[d]	0.67[d]	0.96[bc]	3.72[d]
	(1.61)	(1.08)	(1.21)	(2.05)
White trap	2.04[d]	1.08[bc]	0.88[c]	4.00[d]
	(1.59)	(1.25)	(1.17)	(2.12)
S.Em±	0.057	0.044	0.060	0.051
CD at 5%	0.175	0.135	0.183	0.156

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Table 7. Evaluation of different shapes of traps for their efficacy in capturing fruit flies in guava orchard

Species / Shape of the traps	Mean fruit flies/trap/week		
	B. correcta	*B. dorsalis*	Total fruit flies
Bottles	32.09[a]	0.66[b]	32.75[a]
	(5.71)	(1.07)	(5.76)
Cylinders	31.25[a]	1.80[a]	33.05[a]
	(5.63)	(1.52)	(5.79)
Spheres	22.78[b]	0.34[c]	23.12[b]
	(4.82)	(0.91)	(4.86)
Del-Ta	25.09[b]	0.33[c]	25.42[b]
	(5.06)	(0.91)	(5.09)
Open trap	10.56[c]	0.28[c]	10.84[c]
	(3.33)	(0.88)	(3.36)
S.Em.±	0.115	0.027	0.114
CD at 5%	0.354	0.084	0.351

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Evaluation against *B. dorsalis*

Efficacy of different shapes of traps in capturing *B. dorsalis* fruit flies is presented in Table 7. Cylinder trap attracted significantly highest number of 1.80 fruit flies/trap/week followed by the bottle trap with 0.66 fruit flies/trap/week. Spheres, Del-Ta and open traps were at par with each other and attracted significantly lowest number of fruit flies (0.28 to 0.34 fruit flies/trap/week).

Evaluation against pooled fruit flies

When the fruit flies, irrespective of the species were considered, bottles and cylinders were equally attractive to the fruit flies (32.75 and 33.05 fruit flies/trap/week, respectively) followed by the Del-Ta and sphere traps (25.42 and 23.12 fruit flies/trap/week) (Table 7). The lowest number of trap catches were recorded in the open trap (10.84 fruit flies/trap/week).

4.3.2 Evaluation on the efficacy of different shapes of traps in capturing fruit flies in mango orchard

Evaluation against *B. correcta*

Efficacy of different shapes of traps in capturing *B. correcta* fruit flies is presented in Table 8. Significantly highest number of 3.94 fruit flies/trap/week was captured in bottles followed by the cylinders (2.75 fruit flies/trap/week). Spheres and Del-Ta traps captured next higher number of 2.34 and 2.13 fruit flies/ trap/week respectively. Significantly lowest number of fruit flies was captured in the open trap (1.06 fruit flies/trap/week).

Evaluation against *B. dorsalis*

Spheres captured significantly highest number of *B. dorsalis* (1.38 fruit flies/trap/week) followed by the bottles (0.63 fruit flies/trap/week) which was at par with cylinder trap (0.50 fruit flies/trap/week) (Table 8). Significantly lowest number of fruit flies was captured in the open trap (0.19 fruit flies/trap/week).

Evaluation against *B. zonata*

Bottles, cylinders, spheres, Del-Ta traps were equally effective and captured higher number of 2.66, 2.59, 2.56 and 2.22 fruit flies/trap/week respectively (Table 8). Significantly lowest number of 1.16 fruit flies/trap/week were captured in the open trap.

Evaluation against pooled fruit flies

When the fruit flies irrespective of the species were considered, bottles, spheres and cylinders were found to be significantly superior in attracting higher number of fruit flies (5.84 to 7.23 fruit flies/trap/week) (Table 8). The next higher trap catches was recorded in Del-Ta trap (4.79 fruit flies/trap/week). The lowest trap catches was recorded in the open trap (2.41 fruit flies/trap).

4.4 EVALUATION OF DIFFERENT PROTEIN FOOD BAITS IN ATTRACTING FEMALE FRUIT FLIES IN GUAVA AND MANGO

4.4.1 Evaluation of protein food baits in attracting females of different species in guava

Evaluation against *B. correcta*

Trap baited with proteinex + ammonium acetate (T_7) was the most superior food bait attracting significantly more number of female fruit flies over an exposure of six weeks

Table 8. Evaluation of different shapes of traps for their efficacy in capturing fruit flies in mango orchard

Species / Shape of the traps	Mean fruit flies/trap/week			
	B. correcta	*B. dorsalis*	*B. zonata*	Total fruit flies
Bottles	3.94[a]	0.63[b]	2.66[a]	7.23[a]
	(2.10)	(1.06)	(1.77)	(2.78)
Cylinders	2.75[b]	0.50[bc]	2.59[a]	5.84[b]
	(1.80)	(1.00)	(1.76)	(2.51)
Spheres	2.34[bc]	1.38[a]	2.56[a]	6.28[ab]
	(1.69)	(1.37)	(1.75)	(2.60)
Del-Ta	2.13[c]	0.44[c]	2.22[a]	4.79[c]
	(1.62)	(0.97)	(1.65)	(2.30)
Open trap	1.06[d]	0.19[d]	1.16[b]	2.41[d]
	(1.25)	(0.83)	(1.28)	(1.70)
S.Em.±	0.047	0.027	0.050	0.059
CD at 5%	0.146	0.084	0.154	0.182

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Table 9. Evaluation of different protein food baits in attracting female fruit flies in guava orchard

Treatments \ Species	Mean fruit flies/trap/week			
	B. correcta	*B. dorsalis*	*B. cucurbitae*	Total fruit flies
T_1 – Soybean + sugar + guava pulp (1:1:1) + 5% ammonium acetate	0.42^{e} (0.96)	1.84^{d} (1.53)	1.09^{c} (1.26)	3.35^{d} (1.96)
T_2 – Yeast + sugar + guava pulp (1:1:1) + 5% ammonium acetate	0.84^{d} (1.15)	2.08^{d} (1.60)	1.50^{b} (1.41)	4.42^{d} (2.21)
T_3 – Casein + sugar + guava pulp (1:1:1) + 5% ammonium acetate	0.83^{d} (1.15)	1.92^{d} (1.55)	1.75^{b} (1.50)	4.50^{cd} (2.23)
T_4 – Fruit fly diet + sugar + guava pulp (1:1:1) + 5% ammonium acetate	1.59^{b} (1.44)	2.00^{d} (1.58)	0.25^{ef} (0.87)	3.84^{de} (2.08)
T_5 – Fishmeal + 5% ammonium acetate	1.00^{cd} (1.22)	1.58^{d} (1.44)	0.59^{d} (1.04)	3.17^{e} (1.91)
T_6 – Guava pulp + sugar (1:1) + 5% ammonium acetate	0.75^{d} (1.11)	4.42^{b} (2.21)	0.42^{de} (0.96)	5.59^{b} (2.46)
T_7 – Proteinex + 5% ammonium acetate	5.17^{a} (2.38)	9.42^{a} (3.15)	2.25^{a} (1.66)	16.84^{a} (4.16)
T_8 – Soybean + sugar + guava pulp (1:1:1) + 5% acetic acid	0.17^{e} (0.82)	0.25^{ef} (0.87)	0.17^{f} (0.82)	0.59^{gh} (1.04)
T_9 – Yeast + sugar + guava pulp (1:1:1) + 5% acetic acid	0.17^{e} (0.82)	0.59^{e} (1.04)	0.33^{ef} (0.91)	1.09^{f} (1.26)
T_{10} – Casein + sugar + guava pulp (1:1:1) + 5% acetic acid	0.17^{e} (0.82)	0.17^{f} (0.82)	0.17^{f} (0.82)	0.51^{h} (1.00)
T_{11} – Fruit fly diet + sugar + guava pulp (1:1:1) + 5% acetic acid	0.17^{e} (0.82)	0.17^{f} (0.82)	0.17^{f} (0.82)	0.51^{h} (1.00)
T_{12} – Fishmeal + 5% acetic acid	0.25^{e} (0.87)	0.59^{e} (1.04)	0.25^{ef} (0.87)	1.09^{f} (1.26)
T_{13} – Guava pulp + sugar (1:1) + 5% acetic acid	0.33^{e} (0.91)	0.42^{ef} (0.96)	0.17^{f} (0.82)	0.92^{fg} (1.19)
T_{14} – Proteinex + 5% acetic acid	1.25^{bc} (1.32)	3.50^{c} (2.00)	0.59^{d} (1.04)	5.34^{bc} (2.41)
S.Em±	0.044	0.063	0.038	0.059
CD at 5%	0.136	0.193	0.118	0.180

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

accounting for a mean trap catch of 5.17 fruit flies/traps/week (Table 9). Fruit fly diet + ammonium acetate (T_4) gave the next best response and attracted (1.59 fruit flies/trap/week) followed by the proteinex + acetic acid (T_{14}) with 1.25 fruit flies/trap/week. Food baits containing soybean yeast, casein, fruit fly diet, fishmeal and guava pulp along with acetic acid (T_8, T_9, T_{10}, T_{11}, T_{12} and T_{13}) were least effective.

Evaluation against *B. dorsalis*

Protein food baits containing proteinex + ammonium acetate (T_7) attracted significantly more number of female fruits flies (9.42 fruit flies/trap/week) followed by the trap baited with guava pulp + ammonium acetate (T_6) with catches of 4.42 fruit flies/trap/week (Table 9). The next higher trap catches were recorded in the trap baited with proteinex + acetic acid (T_{14}) (3.5 fruit flies/trap/week) followed by the food baits containing soybean, yeast, casein, fruit fly diet, fishmeal along with ammonium acetate. Significantly lower number of trap catches were recorded in the traps baited with casein and fruit fly diet along with acetic acid (T_{10}, T_{11}) with mean trap catches of 0.17 fruit flies/trap/week.

Evaluation against *B. cucurbitae*

Traps baited with proteinex + ammonium acetate (T_7) attracted significantly more number of female fruit flies (2.25 fruit flies/trap/week) followed by the traps baited with casein (1.75 fruit flies/trap/week), yeast (1.50 fruit flies/trap/week) along with ammonium acetate (T_2 and T_3) (Table 9). The next best catches were recorded in the trap baited with soybean + ammonium acetate (T_1) with mean of 1.09 fruit flies/trap/week. The lowest number of trap catches were recorded in the traps containing soybean, casein, fruit fly diet with acetic acid (T_8, T_{10} and T_{11}).

Evaluation against pooled female fruit flies

Proteinex + ammonium acetate (T_7) captured significantly highest number of 16.84 fruit flies/trap/week followed by guava pulp + ammonium acetate T_6 (5.59 fruit flies/trap/week) which was on par with proteinex + acetic acid (T_{14}) (5.34 fruit flies/trap/week) (Table 9). The next best trap catches were recorded in the traps baited with casein, yeast and fruit fly diet (T_2, T_3, T_4) which were at par with each other. The lowest number of trap catches were recorded in the trap baited with soybean, yeast, casein, fruit fly diet, fishmeal and guava pulp with acetic acid (T_8 to T_{13}) with mean trap catches of 0.51 to 1.09 fruit flies/trap/week.

4.4.2 Evaluation of different protein food baits in attracting female fruit flies in mango orchard

Evaluation against *B. cucurbitae*

Traps baited with mango pulp + ammonium acetate (T_6) and fruit fly diet + ammonium acetate (T_4) attracted significantly more female fruit flies (4.25 and 3.00 fruit flies/trap/week) (Table 10). The next best treatments were mango pulp and proteinex along with acetic acid (T_{13}, T_{14}) which were at par with each other. Fruit flies were not attracted to the bait containing soybean, yeast, casein, fruit fly diet, fishmeal with combination of acetic acid and soybean, fishmeal with combination of ammonium acetate.

Evaluation against *B. dorsalis*

Traps baited with fruit fly diet + ammonium acetate (T_4) attracted significantly more female fruit flies (7.63 fruit flies/trap/week) and was at par with the traps baited with mango pulp + ammonium acetate (T_6) with mean trap catches of 4.63 fruit flies/trap/week (Table 10). The combination of casein + ammonium acetate (T_3) was the next best treatment, (2.93 fruit flies/trap/week) which was at par with the mango pulp + acetic acid (T_{13}) (2.25 fruit flies/trap/week). The lowest number of fruit flies were attracted in the traps baited with yeast + ammonium acetate (T_2) (1.00 fruit flies/trap/week). The remaining treatments did not attract any fruit fly.

Table 10. Evaluation of different protein food baits in attracting female fruit flies in mango orchards

Treatments \ Species	Mean fruit flies/trap/week		
	B. dorsalis	*B. cucurbitae*	Total fruit flies
T_1 – Soybean + sugar + mango pulp (1:1:1) + 5% ammonium acetate	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_2 – Yeast + sugar + mango pulp (1:1:1) + 5% ammonium acetate	1.00^{cd} (1.207)	0.63^{cde} (1.015)	1.63^{cd} (1.45)
T_3 – Casein + sugar + mango pulp (1:1:1) + 5% ammonium acetate	2.93^{bc} (1.827)	0.25^{de} (0.854)	3.18^{bc} (1.91)
T_4 – Fruit fly diet + sugar + mango pulp (1:1:1) + 5% ammonium acetate	7.63^{a} (2.831)	3.00^{ab} (1.825)	10.63^{a} (3.33)
T_5 – Fishmeal + 5% ammonium acetate	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_6 – Mango pulp + sugar (1:1) + 5% ammonium acetate	4.63^{ab} (2.234)	4.25^{a} (2.141)	8.88^{a} (3.06)
T_7 – Proteinex + 5% ammonium acetate	1.88^{c} (1.514)	1.63^{bcd} (1.452)	3.51^{bc} (2.00)
T_8 – Soybean + sugar + mango pulp (1:1:1) + 5% acetic acid	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_9 – Yeast + sugar + mango pulp (1:1:1) + 5% acetic acid	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_{10} – Casein + sugar + mango pulp (1:1:1) + 5% acetic acid	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_{11} – Fruit fly diet + sugar + mango pulp (1:1:1) + 5% acetic acid	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_{12} – Fishmeal + 5% acetic acid	0.00^{d} (0.707)	0.00^{e} (0.707)	0.00^{d} (0.70)
T_{13} – Mango pulp + sugar (1:1) + 5% acetic acid	2.25^{bc} (1.612)	2.38^{bc} (1.685)	4.63^{b} (2.26)
T_{14} – Proteinex + 5% acetic acid	1.63^{c} (1.442)	1.88^{bc} (1.53)	3.51^{bc} (2.00)
S.Em±	0.203	0.217	0.210
CD at 5%	0.622	0.665	0.644

Means followed by the same letters do not differ significantly at p=0.05 by DMRT

Figures in parentheses indicates transformed value ($\sqrt{x+0.5}$)

Evaluation against pooled female fruit flies

When the fruit flies, irrespective of the species were considered, traps baited with fruit fly diet (T_4) and mango pulp (T_6) combined with ammonium acetate attracted significantly more number of female fruit flies (10.63 and 8.88 fruit flies/trap/week, respectively) followed by mango pulp + acetic acid (T_{13}) baited traps (4.63 fruit flies/trap/week) which was at par with casein + ammonium acetate (T_3) and proteinex + acetic acid (T_{14}) 3.18 and 3.51 fruit flies/trap/week, respectively (Table 10). The lowest number of fruit flies were recorded in the traps baited with yeast + ammonium acetate (T_2) (1.63 fruit flies/trap/week). All other treatments failed to attract any fruit fly.

4.5 MONITORING OF THE INCIDENCE OF DIFFERENT SPECIES OF FRUIT FLIES USING METHYL EUGENOL TRAPS IN GUAVA AND MANGO ORCHARDS

4.5.1 Monitoring of the incidence of different species of fruit flies in guava orchard

The highest number of *B. correcta* was trapped during the second week of July 2005 (28th standard week) with trap catches of 255.38 fruit flies/trap/week (Table 11). The catches declined rapidly reaching the lowest catches of 6.25 fruit flies/trap/week during second week of August (33rd standard week). The catches again gradually increased from the fourth week of August (34th standard week) and reached a smaller peak of 26.75 fruit flies/trap/week during second week of October (41st standard week). In 2006 minor peak of 15.13 fruit flies/trap/week was observed during the second week of January (2nd standard week). Trap catches declined rapidly from second week of February to third week of March and then gradually increased reaching the highest peak of 74.63 fruit flies/trap/week during the fourth week of May (21st standard week).

The population of *B. dorsalis* which was at the level of 7.00 fruit flies/trap/week during first week of July, increased gradually attaining the first minor peak of 31.50 fruit flies/trap/week during the third week of July (29th standard week) (Table 11). Thereafter the population declined to the level of 6.38 fruit flies during the second week of August and later it increased reaching the first and second major peaks of 58.50 and 66.38 fruit flies/trap/week during fourth week of October (44th standard week) and fourth week of November, 2005 (48th standard week) respectively. In 2006, the first major peak was observed during the first week of April (14th standard week) with 44.00 fruit flies/trap/week. The smaller peaks of 36.33 and 40.38 fruit flies/trap/week were observed during fourth week of April (17th standard week) and second week of May (19th standard week), respectively.

The population of *B. zonata* was at the lower level throughout the study period (Table 11). The trap catches varied from 0.38 to 16.88 fruit flies/trap/week during 2005. Highest catches were recorded during second week of July (28th standard week) with 16.88 fruit flies/trap/week and then the population rapidly declined till third week of August (34th standard week). With the lowest trap catches of 0.38 fruit flies/trap/week. Thereafter the population increased reaching the next higher peak of 6.75 fruit flies/trap/week during the fourth week of October (44th standard week). In 2006 the highest peak population was observed during 11th standard week (second week of March) with 6.5 fruit flies/trap/week and lowest peak population was observed during fourth week of January (4th standard week) with 0.88 fruit flies/trap/week.

When the total fruit flies were considered irrespective of the species (Table 11), the first major peak population of 282.63 fruit flier/trap/week was observed during second week of July (28th standard week). The population declined to 31.50 fruit flies/trap/week during fourth week of July (30th standard week) and remained more or less at the same level from fourth week of August (35th standard week) to first week of October (40th standard week).

Table 11. Methyl eugenol trap catches of different species of fruit flies from July 2005 to May 2006 in guava orchard at UAS, Dharwad

Date	Standard week	Trap catches per week*			
		B. correcta	**B. dorsalis**	**B. zonata**	Total
1-7 July	27	70.88	7.00	6.75	84.63
8-14	28	255.38	10.38	16.88	282.63
15-21	29	62.00	31.50	2.13	95.63
22-28	30	19.13	11.75	0.63	31.50
29 July-4 August	31	17.38	13.00	1.13	31.50
5-11	32	10.50	12.25	1.50	24.25
12-18	33	6.25	6.38	0.63	13.25
19-25	34	9.38	9.13	0.38	18.88
26 August - 2 September	35	15.63	13.50	2.13	31.25
3-8	36	16.13	13.88	1.75	31.75
9-15	37	13.88	9.25	2.00	25.13
16-22	38	15.50	23.13	1.50	40.13
23-29	39	12.75	15.38	2.63	30.75
30 September - 6 October	40	24.75	13.38	3.50	41.63
7-13	41	26.75	21.88	4.13	52.75
14-20	42	9.50	36.75	4.75	51.00
21-27	43	8.63	44.88	5.38	58.88
28 October - 3 November	44	6.88	58.50	6.75	72.13
4-10	45	12.13	25.13	6.13	43.38
11-17	46	14.00	28.13	4.00	46.13
18-24	47	13.88	25.00	4.75	43.63
25 November - 1 December	48	15.00	66.38	3.88	85.25
2-8	49	2.25	61.50	5.25	69.00
9-15	50	1.25	25.13	2.25	28.63
16-22	51	1.75	16.75	2.38	20.88
23-31	52	1.88	19.13	2.50	23.50

Table 11. Contd…..

Date	Standard week	Trap catches per week*			
		B. correcta	**B. dorsalis**	**B. zonata**	Total
1-7 January	1	14.63	13.13	1.25	29.00
8-14	2	15.13	3.88	1.38	20.38
15-21	3	5.50	2.63	1.13	9.25
22-28	4	4.00	2.88	0.88	7.75
29 January - 4 February	5	6.88	11.00	5.13	23.00
5-11	6	7.25	11.38	2.63	21.25
12-18	7	7.13	9.25	5.63	22.00
19-25	8	5.75	7.63	2.63	16.00
26 February - 4 March	9	2.63	7.88	5.25	15.75
5-11	10	3.00	7.25	3.88	14.13
12-18	11	2.50	16.25	6.50	25.25
19-25	12	2.13	11.00	5.25	18.38
26 March - 1 April	13	7.38	22.75	4.63	34.75
2-8	14	5.38	44.00	1.13	50.50
9-15	15	16.88	8.00	2.13	27.00
16-22	16	24.88	32.38	4.00	61.25
23-29	17	24.63	36.63	5.38	66.63
30 April - 6 May	18	25.63	29.75	5.25	60.63
7-13	19	31.00	40.38	2.88	74.25
14-20	20	46.13	32.38	5.88	84.38
21-27	21	74.63	30.38	6.00	111.00

* Average of eight traps

The second peak catches of 72.13 during fruit flies/trap/week was observed in fourth week of October (44th standard week) followed by a third peak of 85.25 fruit flies/trap/week during fourth week of November (48th standard week).

In 2006 two peaks were observed with the first minor peak during first week of April (14th standard week) with mean trap catches of 50.50 fruit flies/trap/week followed by the second major peak during fourth week of May (111.00 fruit flies/trap/week).

4.5.2 Monitoring of incidence of different species of fruit flies in mango orchard

The first major peak of *B. correcta* was observed during second week of July 2005 (28th standard week) with trap catches of 155.38 fruit flies/trap/week (Table 12). The catches declined rapidly reaching the lowest catches of 2.88 fruit flies/trap/week during second week of August (33rd standard week). The catches again gradually increased and two minor peaks were recorded during 35th standard week (fourth week of August) and 47th standard week (third week of November) with mean of 36.38 and 30.13 fruit flies/trap/week respectively. In 2006, the first peak of 11.75 fruit flies/trap/week was observed during second week of January (2nd standard week). Trap catches remained more or less at the same level till the first week of March (9th standard week) and then declined. The second peak population (25.25 fruit flies/trap/week) was recorded during fourth week of April (17th standard week) and the third peak during third week of May with 64.38 fruit flies/trap/week.

The population of *B. dorsalis* which was at the level of 146.25 fruit flies/trap/week during first week of July, increased in the following week attaining the first major peak of 168.5 fruit flies/trap/week (28th standard week) (Table 12). Thereafter the population declined to the level of 8.38 fruit flies during third week of August (34th standard week). The population fluctuation was at the same level from fourth week of August to last week of October and later it increased reaching the second major peak of 145.13 fruit flies/trap/week during third week of November (47th standard week). Then the catches declined again rapidly with mean of 4.25 fruit flies during fourth week of December (52nd standard week). In 2006, the first peak was observed during fourth week of March (13th standard week) with 64.13 fruit flies/trap/week. The trap catches increased from third week of April and the second major peak of 249.00 fruit flies/trap/week was observed during third week of May (20th standard week) and then population declined.

The population of *B. zonata* was at the lower level throughout the study period (Table 12). The trap catches varied from 0.37 to 7.25 fruit flies/trap/week during 2005. Four peaks of 3.25, 7.25, 6.38 and 4.75 fruit flies/trap/week were observed during second week of July (28th standard week), fourth week of September (39th standard week), third week of October (42nd standard week) and third week of November of 2005 (47th standard week) respectively. In 2006 also, four peaks were observed during second week of January (4.25 fruit flies/trap/week), third week of March (22.63 fruit flies/trap/week), first week of April (26.88 fruit flies/trap/week) and fourth week of May (37.25 fruit flies/trap/week).

When the total fruit flies were considered irrespective of the species, the first major peak population of 327.13 fruit flies/trap/week was observed during second week of July (28th standard week) (Table 12). The population declined to 13.75 fruit flies/trap/week during third week of August (34th standard week). Thereafter the population increased to 58.50 fruits flies/trap/week and fluctuated at the same level from fourth week of August (35th standard week) to fourth week of October (43rd standard week). A further increasing trend in the population was observed from the fourth week of October with the second peak of 180.00 fruit flies/trap/week during third week of November (47th standard week). Thereafter population declined gradually. In 2006, two peaks were observed with the first minor peak during fourth week of March (13th standard week) with mean catches of 86 fruit flies/trap/week and the second major peak during third week of May (341.75 fruit flies/trap/week).

Table 12. Methyl eugenol trap catches of different species of fruit flies from July 2005 to May 2006 in mango orchard at UAS, Dharwad

Date	Standard week	Trap catches per week*			
		B. correcta	**B. dorsalis**	**B. zonata**	Total
1-7 July	27	111.63	146.25	1.25	259.13
8-14	28	155.38	168.50	3.25	327.13
15-21	29	45.25	80.38	0.88	126.50
22-28	30	10.50	16.13	0.50	27.13
29 July-4 August	31	3.88	15.13	0.38	19.38
5-11	32	3.63	17.13	0.38	21.13
12-18	33	2.88	11.13	0.63	14.63
19-25	34	4.63	8.38	0.75	13.75
26 August - 2 September	35	36.38	20.88	1.25	58.50
3-8	36	29.25	11.88	3.00	44.13
9-15	37	31.38	13.13	2.25	46.75
16-22	38	15.13	16.88	3.25	35.25
23-29	39	25.63	17.88	7.25	50.75
30 September - 6 October	40	5.38	31.88	5.50	42.75
7-13	41	8.00	17.88	3.63	29.50
14-20	42	8.88	24.00	6.38	39.25
21-27	43	5.50	21.13	2.88	29.50
28 October - 3 November	44	12.25	59.75	2.38	74.38
4-10	45	19.38	79.38	1.13	99.88
11-17	46	25.63	94.75	1.75	122.13
18-24	47	30.13	145.13	4.75	180.00
25 November - 1 December	48	26.00	97.88	3.00	126.88
2-8	49	14.75	32.38	1.00	48.13
9-15	50	4.38	12.13	0.75	17.25
16-22	51	3.63	5.63	1.00	10.25
23-31	52	2.75	4.25	0.63	7.63

Table 12. Contd……

Date	Standard week	Trap catches per week*			
		B. correcta	**B. dorsalis**	**B. zonata**	Total
1-7 January	1	1.50	3.13	0.38	5.00
8-14	2	11.75	7.13	4.25	23.13
15-21	3	9.25	4.88	0.50	14.63
22-28	4	8.75	3.13	2.63	14.50
29 January - 4 February	5	10.13	6.13	3.25	19.50
5-11	6	5.38	7.63	8.13	21.13
12-18	7	6.00	8.13	10.13	24.25
19-25	8	6.25	9.38	11.13	26.75
26 February - 4 March	9	11.38	15.00	11.75	38.13
5-11	10	3.50	6.38	13.13	23.00
12-18	11	1.50	1.00	21.00	23.50
19-25	12	1.88	1.13	22.63	25.63
26 March - 1 April	13	6.75	64.13	15.13	86.00
2-8	14	4.63	17.13	26.88	48.63
9-15	15	5.25	41.38	24.25	70.88
16-22	16	16.38	32.88	17.00	66.25
23-29	17	25.25	35.75	15.63	76.63
30 April - 6 May	18	10.38	44.63	17.75	72.75
7-13	19	37.38	70.63	19.25	127.25
14-20	20	64.38	249.00	28.38	341.75
21-27	21	44.38	166.13	37.25	247.75

* Average of eight traps

4.6 INFLUENCE OF WEATHER PARAMETERS ON TRAP CATCHES IN GUAVA AND MANGO ORCHARDS

Studies were made to find out the relationship between trap catches of different species of fruit flies and weather parameters such as maximum and minimum temperature, morning and afternoon relative humidity and rainfall.

4.6.1 Guava

B. correcta had a significant positive correlation with minimum temperature (r=0.327*) (Table 13). There was no significant relationship with other weather parameters. The trap catches were influenced to an extent of 12.3 per cent by all weather parameters (Table 14). The multiple linear regression model fitted was

$Y = 61.326-5.092x_1+6.396x_2+0.633x_3-1.061x_4-0.158x_5$

Where,

x_1 = Maximum temperature
x_2 = Minimum temperature
x_3 = Morning relative humidity
x_4 = Afternoon relative humidity
x_5 = Rainfall

Trap captures of *B. dorsalis* had no significant relationship with any of the weather parameters (Table 13). Weather factors collectively influenced trap catches to an extent of 6.9 per cent (Table 14). The multiple linear regression model fitted was

$Y = 21.328-0.686x_1+1.665x_2+7.276x_3-0.322x_4-0.11x_5$

Trap catches of *B. zonata* had non-significant relationship with weather parameters (Table 13). All the weather factors together influenced the trap catches to an extent of 11.8 per cent (Table 14). The multiple linear regression model fitted was

$Y = 11.405-0.300x_1+0.499x_2+6.264x_3-4.946x_4-0.115x_5$

4.6.2 Mango

In case of *B. correcta*, trap catches had high significant positive correlation with minimum temperature (r=0.324*) (Table 15). The multiple linear regression model fitted was

$Y = 25.66-0.153x_1+2.241x_2+9.725x_3+5.646x_4+0.088x_5$

The weather factors together influenced the trap catches to an extent of 11.2 per cent (Table 16).

Trap catches of *B. dorsalis* showed no significant relation with the weather parameters (Table 15). The trap catches were influenced to an extent of 10.1 per cent by all the parameters together (Table 16). The multiple linear regression model fitted was

$Y = -32.766-0.492x_1+5.944x_2+0.214x_3-0.744x_4+0.019x_5$

The trap catches of *B. zonata*, had highly significant positive correlation with maximum temperature (r=0.815**) and highly negative correlation with afternoon relative humidity (r=-0.537**) (Table 15). Rainfall had significantly negative correlation (r=-0.293*). However, the trap catches were influenced to an extent of 69.4 per cent by weather parameters collectively (Table 16). The multiple linear regression model fitted was

$Y = -48.042+1.437x_1+0.861x_2+2.568x_3-0.124x_4-0.111x_5$

Table 13. Correlation coefficients of trap catches with weather parameters in guava orchard

Fruit fly species	Temperature (℃)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Afternoon	
B. correcta	-0.019	0.327*	0.262	0.201	0.107
B. dorsalis	0.216	0.138	-0.019	-0.112	-0.085
B. zonata	0.170	0.066	-0.173	-0.153	-0.153

n=48 and table r value at 5% is 0.288 and at 1% is 0.372
* Significant at 5%
** Significant at 1%

Table 14. Multiple linear regression coefficient of trap catches with weather parameters in guava orchard

Fruit fly species	Intercept	Temperature (℃)		Relative humidity (%)		Rainfall (mm)	R^2
		Maximum	Minimum	Morning	Afternoon		
B. correcta	61.326	-5.092	6.396	0.633	-1.061	-0.158	0.123
B. dorsalis	21.328	-0.686	1.665	7.276	-0.322	-0.111	0.069
B. zonata	11.405	-0.300	0.499	-6.264	-4.946	-0.115	0.118

Table 15. Correlation coefficients of trap catches with weather parameters in mango orchard

Fruit fly species	Temperature (℃)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Afternoon	
B. correcta	-0.045	0.324*	0.273	0.242	0.254
B. dorsalis	0.224	0.239	0.060	-0.050	0.038
B. zonata	0.815**	0.236	-0.218	-0.537**	-0.293*

n=48 and table r value at 5% is 0.288 and at 1% is 0.372
* Significant at 5%
** Significant at 1%

Table 16. Multiple linear regression coefficient of trap catches with weather parameters in mango orchard

Fruit fly species	Intercept	Temperature (℃)		Relative humidity (%)		Rainfall (mm)	R^2
		Maximum	Minimum	Morning	Afternoon		
B. correcta	25.66	-0.153	2.241	9.725	5.646	0.088	0.112
B. dorsalis	-32.766	-0.492	5.944	0.214	-0.744	0.019	0.101
B. zonata	-48.042	1.437	0.861	2.568	-0.124	-0.111	0.694

V. DISCUSSION

Results of the studies on evaluation of different quantities of methyl eugenol and frequency of charging, efficacy of different colours and shapes of traps, evaluation of protein food baits against female fruit flies, monitoring, relationship between trap catches and weather parameters are discussed in this chapter.

5.1 EVALUATION ON THE QUANTITY AND FREQUENCY OF CHARGING OF THE TRAPS WITH METHYL EUGENOL IN GUAVA AND MANGO ORCHARDS

5.1.1 Evaluation of the different quantities of methyl eugenol in trapping fruit flies in guava and mango orchards

Methyl eugenol, a parapheromone is known to attract 69 species of fruit flies (Drew, 1974; 1989; Drew and Hancock, 1994) and it is being widely used for male annihilation technique for management of *Bactrocera* spp (White and Elson Harris, 1992). Drew *et al*. (1982) recommended use of dichlorovos along with methyl eugenol for successful kill of fruit flies.

In the present studies, traps charged with 0.1 and 0.2 ml methyl eugenol + 1 ml dichlorovos attracted significantly more *B. correcta* while *B. dorsalis* and total fruit flies were attracted to the traps charged with 0.1 ml methyl eugenol in guava (Table 1). However, the traps charged with 0.2 ml methyl eugenol were superior to all the species of fruit flies in mango (Table 2). As the quantity of methyl eugenol increased, the trap catches declined significantly in both the crops. The POP trap proved to be the most inferior trap. The poor performance of the POP trap was attributed to the faster evaporation of water containing methyl eugenol. These traps were dried up within 4 to 5 days under field conditions.

Effective control of *B. dorsalis* has been reported by use 1 per cent methyl eugenol by Balasubramaniam *et al*. (1972) and Lakshmanan *et al*. (1973). Belavadi (1979) reported 0.075 ml methyl eugenol on the most effective against *B. dorsalis* in guava which is almost in line with the prevent result. Similarly Cunningham *et al*. (1975) reported 83 per cent methyl eugenol is effective against *B. dorsalis*.

Rahman (1990), Singh (1993) and Makmoor and Singh (1998) reported 0.5 per cent of methyl eugenol as most effective in trapping *B. dorsalis*. Liu (1991) and Liu and Lin (1992) reported a mixture of 10 per cent methyl eugenol and 90 per cent cue lure and 20 per cent methyl eugenol and 80 per cent cue lure attracted more number of fruit flies. However, the present study clearly reveal that 0.1 and 0.2 ml methyl eugenol along with 1 ml dichlorovos is most effective.

5.1.2 Evaluation on the frequency of charging of methyl eugneol in trapping fruit flies in guava and mango orchards

Charging the traps with methyl eugenol either at 1 or 2 or 3 or 4 weeks interval had no influence on trap catches of *B. correcta* in guava (Table 3). Similarly in mango, charging at 1, 2 or 3 weeks interval had no impact on the trap catches (Table 4). The results clearly indicate that traps once charged with methyl eugenol can be run effectively upto four weeks. Similar results were obtained in case of *B. dorsalis* in mango but in guava charging at fortnight interval proved to be better option. The catches of *B. zonata* in the traps charged at either at 1, 2, 3 or 4 weeks did not differ indicating requirement of charging only at 4 weeks interval (Table 4).

When the pooled data were considered irrespective of species, a similar trend was observed both in guava and mango. The present results are in line with the findings of Balasubramaniam *et al*. (1972), Lakshmanan *et al*. (1975) and Belvadi (1979) who reported

that single charging of methyl eugenol was most effective upto one month for trapping fruit flies.

5.2 EVALUATION ON THE EFFICACY OF DIFFERENT COLOURED TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARD

Evaluation against *B. correcta*

In guava, yellow colour traps attracted highest number of *B. correcta* (70.45 fruit flies/trap/week) followed by transparent (55.50 fruit flies/trap/week) while in mango, the trend was reverse (Table 5 and 6).

Present results endorse the findings of Vargas *et al*. (1991), Stark and Vargas (1992), Jalaluddin *et al*. (1998), Madhura (2001), Sarada *et al*. (2001a) who observed greater preference of fruit flies towards yellow and transparent traps. Preference of yellow colour traps by *A. ludens* is also reported by Robacker *et al*. (1990). *C. capitata* preferred the trap with yellow band (Heath *et al*., 1995). Similar results were obtained by Rajitha and Viraktamath (2005a, b).

Evaluation against *B. dorsalis*

In guava, green and orange coloured traps attracted significantly more number of fruit flies (3.79 and 3.75 fruit flies/trap/week) (Table 5). However, in mango it showed highest preference to black (3.88 fruit flies/trap/week) followed by orange and transparent traps (Table 6).

Fruit flies respond to colours that are similar to oviposition host such as green, orange and yellow (Vargas *et al*., 1991 and Cornelius *et al*., 1999). Reflectance of yellow and orange colour might also be a factor in the attractiveness of fruit flies to these colours (Robacker *et al*., 1990; Stark and Vargas, 1992). Present results endorse these reports. Similarly Rajitha and Viraktamath (2005a, b) also reported that transparent, orange and green colour traps were attractive to *B. dorsalis*. In mango, *B. dorsalis* showed interestingly highest preference to black traps. Similar preference to black colour is also shown by *C. capitata* (Nakagawa *et al*., 1978).

Evaluation against *B. zonata*

Red colour trap had the highest influence on the trap catches of *B. zonata* (3.70 fruit flies/trap/week) followed by the transparent trap (Table 6).

Present results are in conformity with the reports of Rajitha and Viraktamath (2005a, b). Similarly red traps were also preferred by *R. pomonella* (Prokopy, 1968a, 1973, 1977).

Variations in the response of *B. correcta*, *B. dorsalis* and *B. zonata* in guava and mango was probably due to the different level of population prevailing in these orchards.

Evaluation against total fruit flies

When all the fruit flies were considered irrespective of species yellow traps were more attractive followed by the transparent trap in guava. In mango black trap was preferred followed by the transparent and red traps (Fig. 1).

Present results are in conformity with the reports of Jalaluddin *et al*. (1998) and Madhura (2001) who reported *Bactrocera* spp. being attracted to yellow colour traps. Similarly yellow colour is attractive to many tephritid fruit flies as reported by Prokopy and Owens (1983).

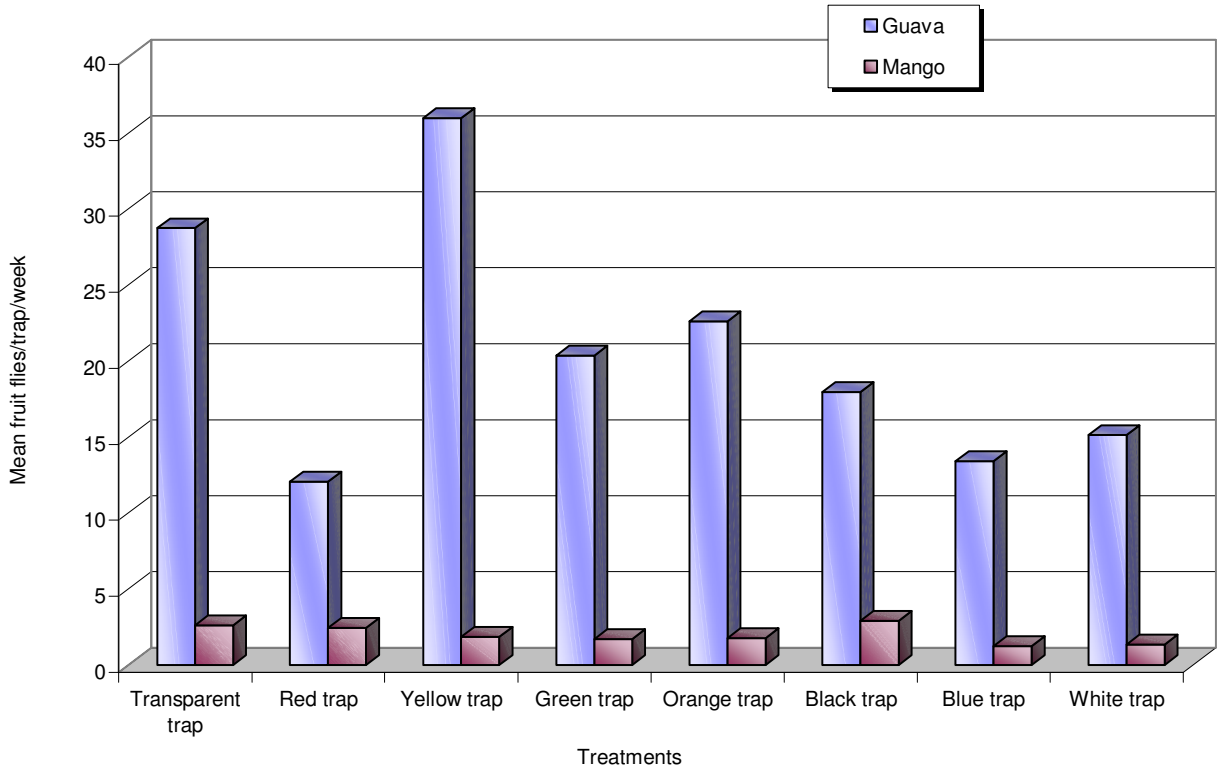


Fig. 1. Evaluation on the efficacy of different coloured traps in capturing fruit flies in guava and mango orchard

Fig. 1. Evaluation on the efficacy of different coloured traps in capturing fruit files in guava and mango orchard

5.3 EVALUATION ON THE EFFICACY OF DIFFERENT SHAPES OF TRAPS IN CAPTURING FRUIT FLIES IN GUAVA AND MANGO ORCHARDS

Evaluation against *B. correcta*

Bottles and cylinders were significantly more attractive with higher trap catches of 32.09 and 31.25 fruit flies/trap/week respectively followed by spheres and Del-Ta trap in guava (Table 7). In mango, bottles were superior followed by cylinders and spheres (Table 8).

Present results endorse the findings Rajitha and Viraktamath (2005a, b) who reported that cylinders and bottles were more preferred by *B. correcta* in guava and mango respectively.

Evaluation against *B. dorsalis*

In guava, cylinder traps had significant influence on trap catches followed by the bottle (Table 7). In mango spheres had significant influence followed by the bottle (Table 8).

Present results endorse the findings of Vargas *et al*. (1991) and Rajitha and Viraktamath (2005a, b). According to Nakagawa *et al*. (1978), Cornelius *et al*. (1999), Mayer *et al*. (2000) and Liburd *et al*. (2000) spheres constitute a super normal fruit type visible stimulus thus attracting more fruit flies.

Evaluation against *B. zonata*

In mango, bottles, cylinders, spheres, Del-Ta trap had equal influence on trap catches (Table 8).

Present results are in conformity with the reports of Rajitha and Viraktamath (2005b).
Evaluation against total fruit flies

When all the fruit flies irrespective of species were pooled, bottles and cylinders significantly attracted more fruit flies followed by the spheres and Del-Ta in guava. In mango, bottles were more preferred followed by the cylinders and spheres (Fig. 2).

These results endorse the findings of earlier studies which have shown that response of fruit flies to visual stimuli were dependent on colour, shape and size of the stimulus (Prokopy, 1968; Economopoulos, 1989; Katsoyannos, 1989). Lower captures of fruit flies in the open trap both in guava and mango was attributed to the quick dispersal of methyl eugenol in these traps.

5.4 EVALUATION DIFFERENT PROTEIN FOOD BAITS IN ATTRACTING FEMALE FRUIT FLIES IN GUAVA AND MANGO ORCHARD

Female fruit flies need to feed on protein diet to attain sexual maturity as reported by Christenson and Foote (1960). This basic need of the female fruit flies has been exploited in developing systems to attract female fruit flies (Epsky *et al*., 1999 and Mazor *et al*., 2002). In the present study a bait containing proteinex, guava pulp, casein and yeast with 5 per cent ammonium acetate were promising in attracting significantly more female fruit flies in guava. In mango, mango pulp, fruit fly diet, casein with 5 per cent ammonium acetate were promising. However, protein baits with combination of 5 per cent acetic acid did not attract as many fruit flies as the ammonium acetate (Fig. 3).

Ammonium acetate is reported as most effective in attracting the fruit flies by Reissig (1976). Oatman (1964) also used house hold ammonia effectively in controlling the fruit flies. Protein source as an important component in the food baits and commercial lures has been

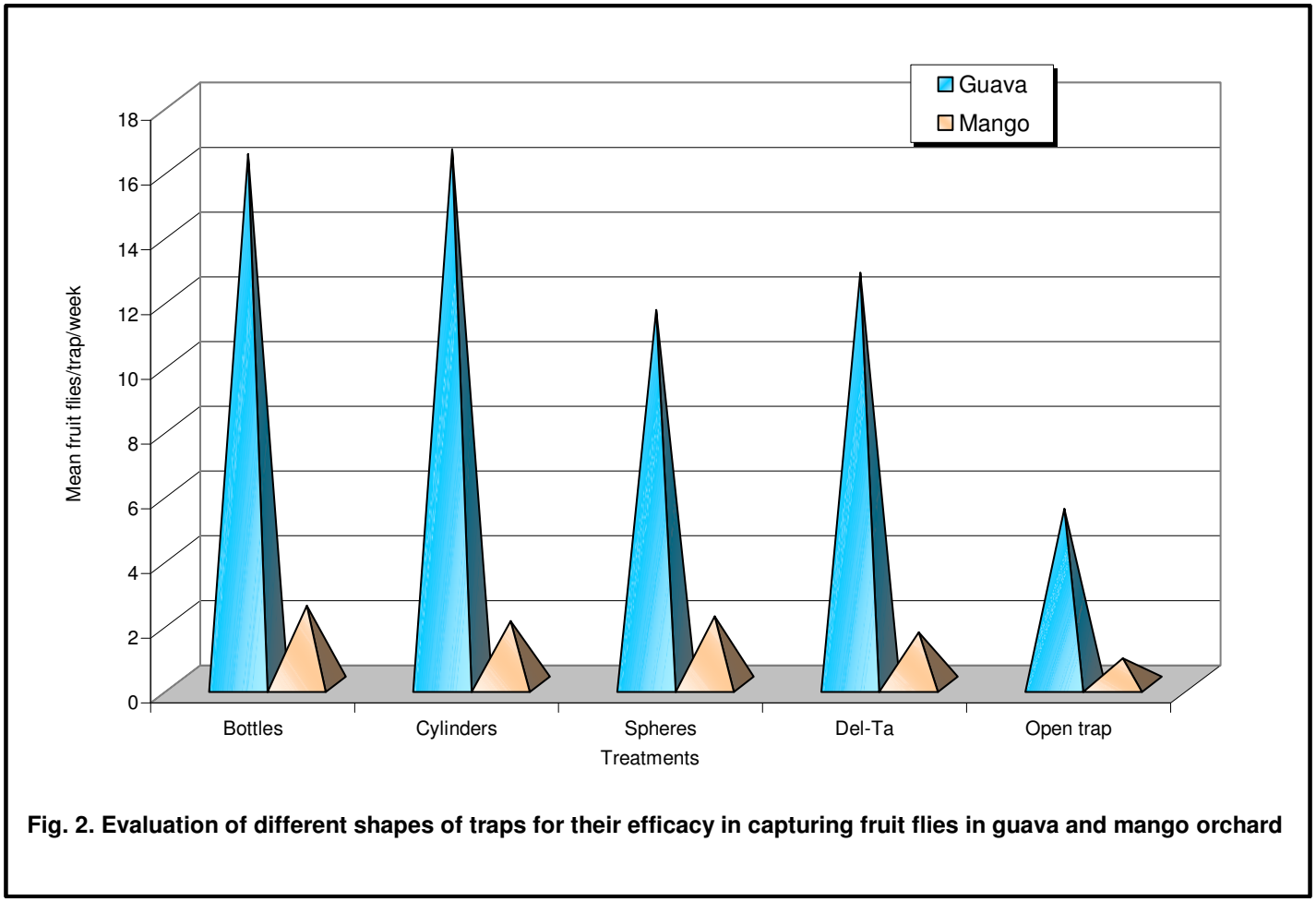


Fig. 2. Evaluation of different shapes of traps for their efficacy in capturing fruit flies in guava and mango orchard

Fig. 2. Evaluation of different shapes of traps for their efficacy in capturing fruit files in guava and mango orchard

documented with *B. cucurbitae* (Steiner, 1952, Narayanan and Batra, 1960, Vijaysegaran, 1985; Satpathy and Samarjith Rai, 2002, Fabre *et al*., 2003) and *B. dorsalis* (Steiner, 1952; Narayanan and Batra, 1960; Alyokhin *et al*., 2000 and Cornelius *et al*., 2000). Present results endrose these reports. Present results are also in line with the reports of Rajitha and Viraktamath (2005c) and Ravikumar (2005).

5.5 MONITORING THE INCIDENCE OF DIFFERENT SPECIES OF FRUIT FLIES USING METHYL EUGENOL TRAPS IN GUAVA AND MANGO ORCHARDS

5.5.1 Guava

B. correcta had the first major peak during second week of July (255.38 fruit flies/trap/week) and one minor peak during second week of October (26.75 fruit flies/trap/week) in 2005. In 2006, minor peak was recorded during second week of January (15.13 fruit flies/trap/week) and a major peak during last week of May (76.63 fruit flies/trap/week) (Fig. 4).

Present results endorse the findings of Jalaluddin *et al*. (2001), Viraktamath and Suresh Babu (2004), Ravikumar (2005) and Rajitha and Viraktamath (2006a) who reported peak catches of *B. correcta* from July to August and October to November.

B. dorsalis had three peaks during third week of July (21.5 fruit flies/trap/week), fourth week of October (58.50 fruit flies/trap/week) and fourth week of November (66.38 fruit flies/trap/week) in 2005. In 2006 one peak occurred during first week of April (44.00 fruit flies/trap/week) (Fig. 5).

Present results endrose the findings of Narayanan and Batra (1960) and Mann (1996) who also reported peak catches from July to October. However, Vargas *et al*. (1989) and Prasad and Bagle (1978) reported peak catches in April month. Similarly Jalaluddin *et al*. (2001) and Ravikumar (2005) reported three peak catches.

Though population of *B. zonata* was recorded throughout the year, the catches were relatively low ranging from 0.38 to 16.88 fruit flies/trap/week. Three peak catches were recorded during second week of July, last week of October and second week of March (16.88, 6.75, 6.5 fruit flies respectively) (Fig. 6).

These results are in agreement with the report of Narayanan and Batra (1960), Rajitha and Viraktamath (2006a) and Ravikumar (2005) who reported peak catches during November and March month.

When the total number of fruit flies were considered, irrespective of the species, three peaks were observed during second week of July, last week of November and last week of May with mean trap catches of 282.63, 85.23, 111.00 fruit flies/trap/week respectively (Fig. 7).

The peak catches during July and November were attributed to the peak fruiting of guava while the peak noticed in May was due to peak fruiting period of mango in the surrounding orchards.

These observations are in conformity with the observations of Sarda *et al*. (2001b) and Narayanan and Batra (1960). Similarly, Ravikumar (2005) also reported peak catches during 27^{th}, 45^{th}, 48^{th}, 21^{st} standard weeks.

5.5.2 Mango

B. correcta had the first major peak during second week of July with highest captures of 155.37 fruit flies/trap/week and one minor peak during third week of November (30.13 fruit flies/trap/week) in 2005. In 2006, a major peak was observed during third week of May (64.37 fruit flies/trap/week) (Fig. 8).

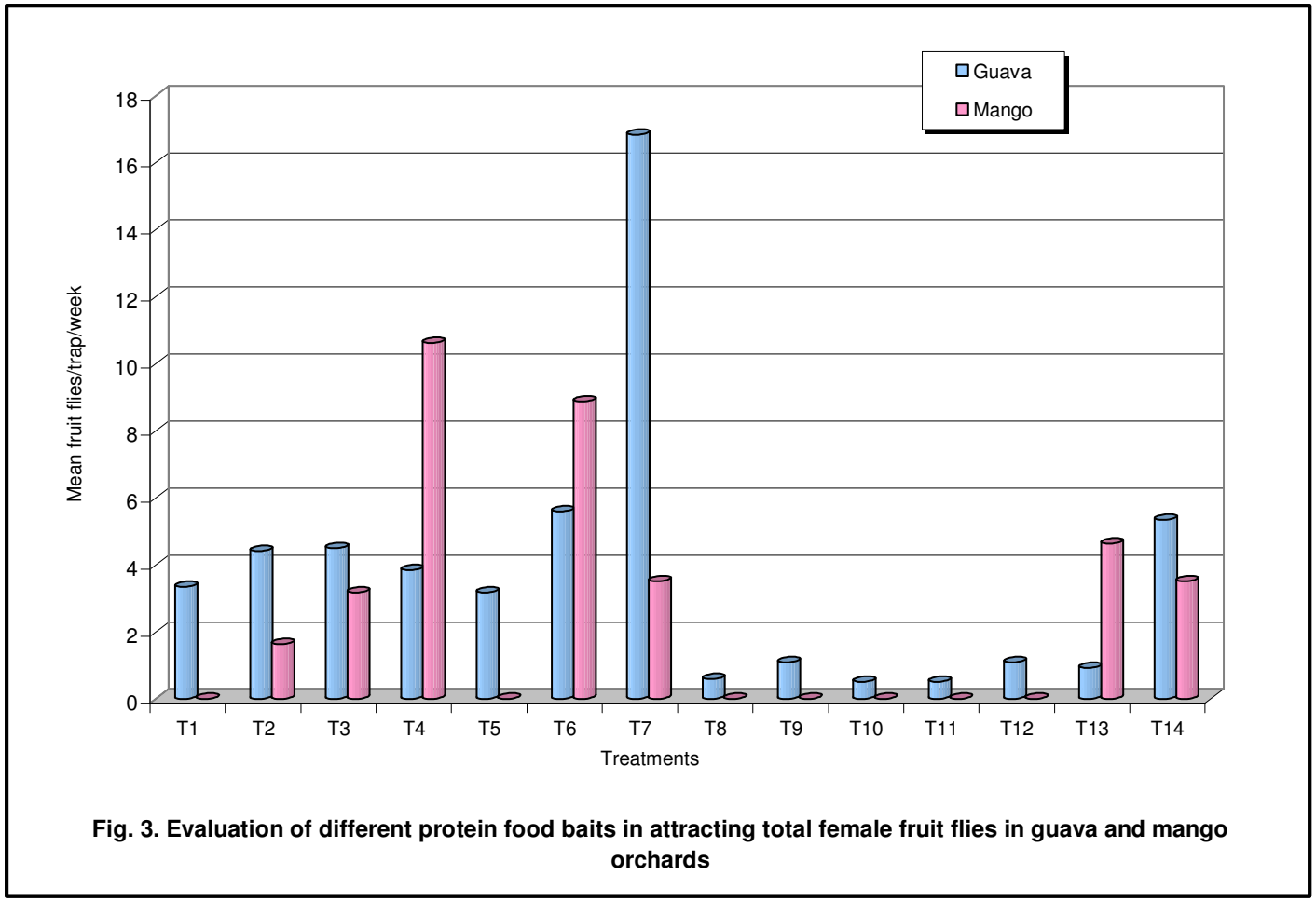


Fig. 3. Evaluation of different protein food baits in attracting total female fruit flies in guava and mango orchards

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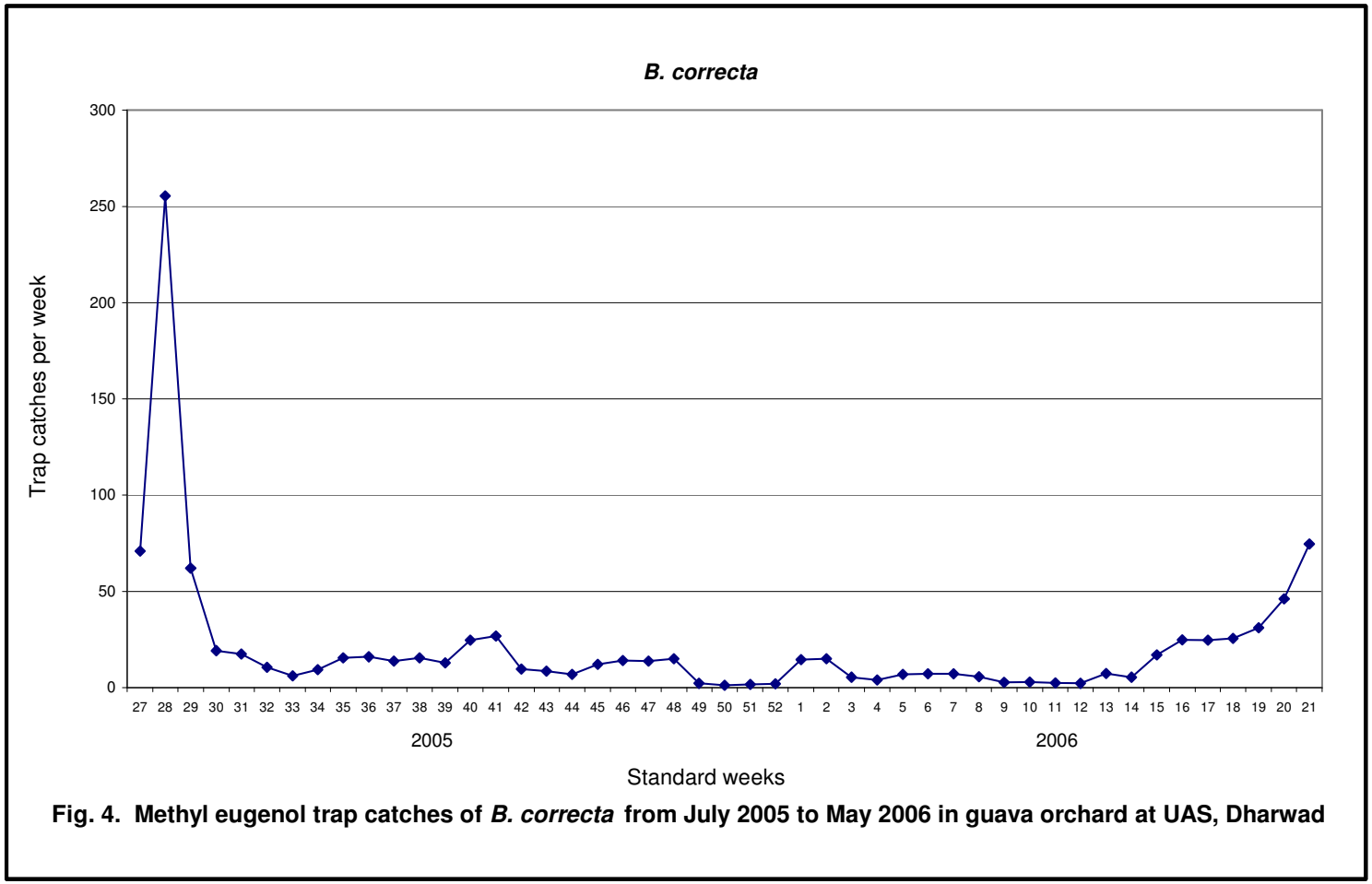

Fig. 4. Methyl eugenol trap catches of *B. correcta* from July 2005 to May 2006 in guava orchard at UAS, Dharwad

Fig. 4. Methyl eugenol trap catches of B. correcta from July 2005 to May 2006 guava orchard at UAS, Dharwad

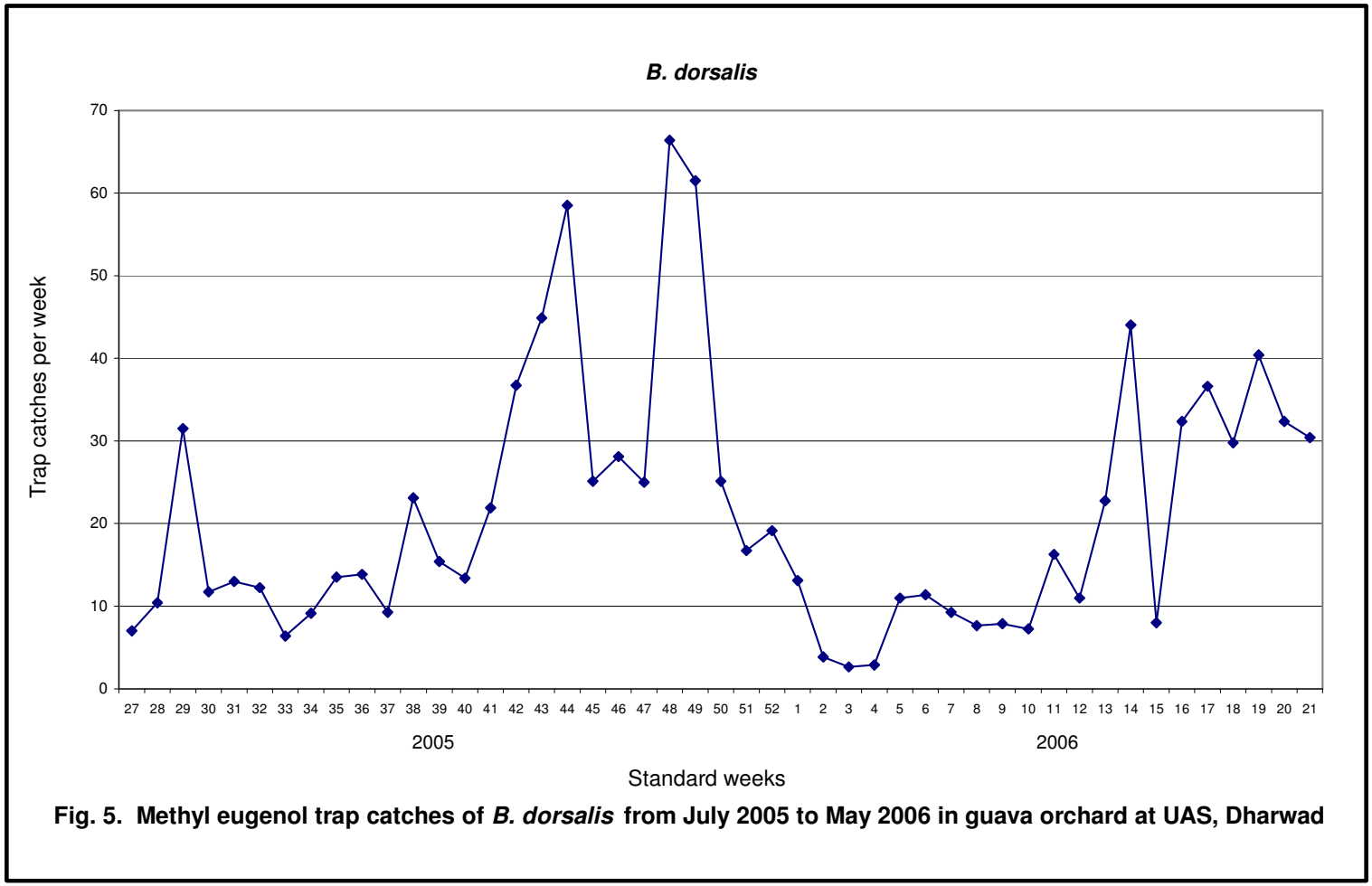

Fig. 5. Methyl eugenol trap catches of *B. dorsalis* from July 2005 to May 2006 in guava orchard at UAS, Dharwad

Fig. 5. Methyl eugenol trap catches of B. dorsalis from July 2005 to May 2006 in guava orchard at UAS, Dharwad

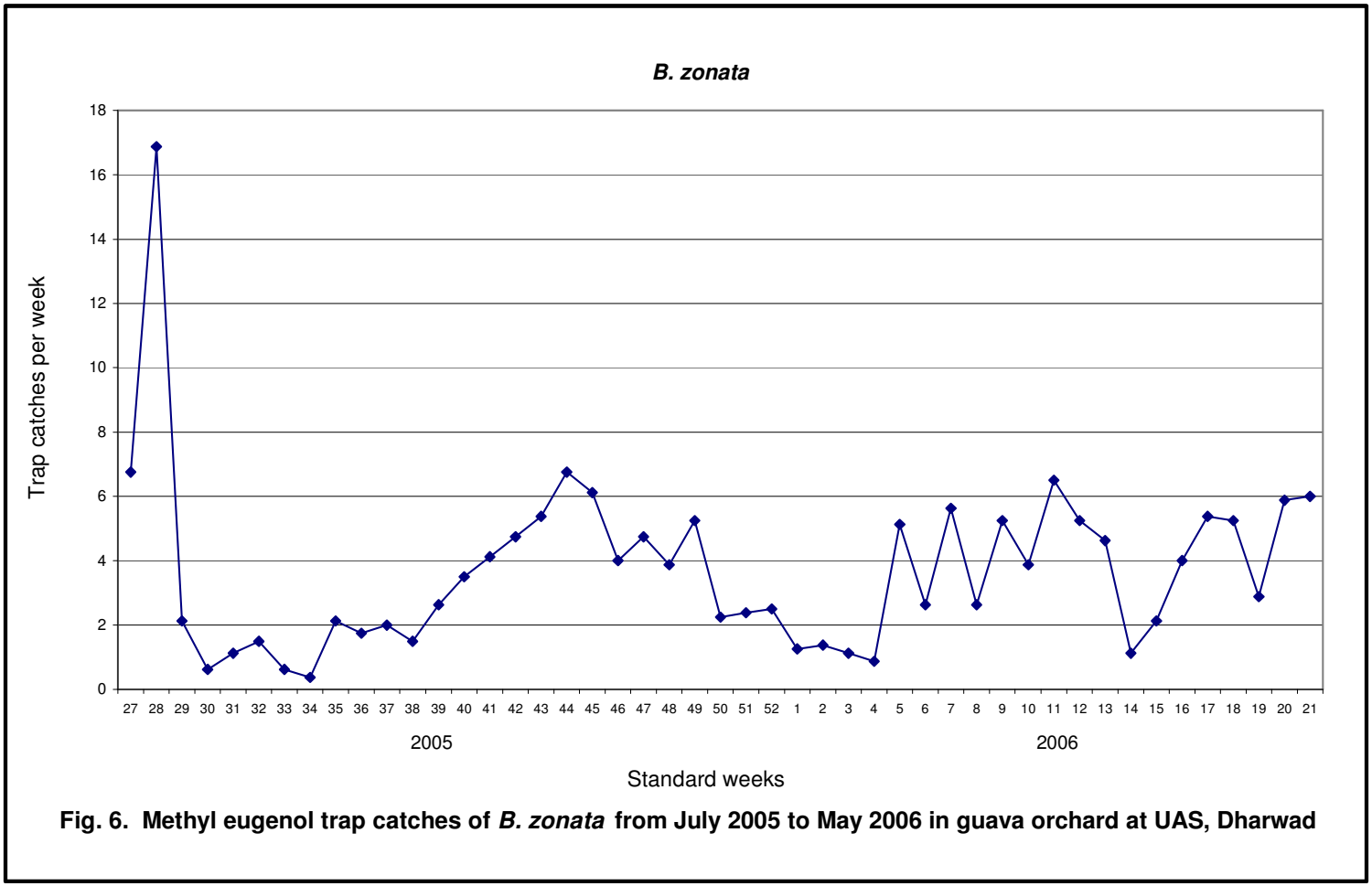

Fig. 6. Methyl eugenol trap catches of *B. zonata* from July 2005 to May 2006 in guava orchard at UAS, Dharwad

Fig. 6. Methyl eugenol trap catches of B. Zonata from July 2005 to May 2006 in guava orchard at UAS, Dharwad

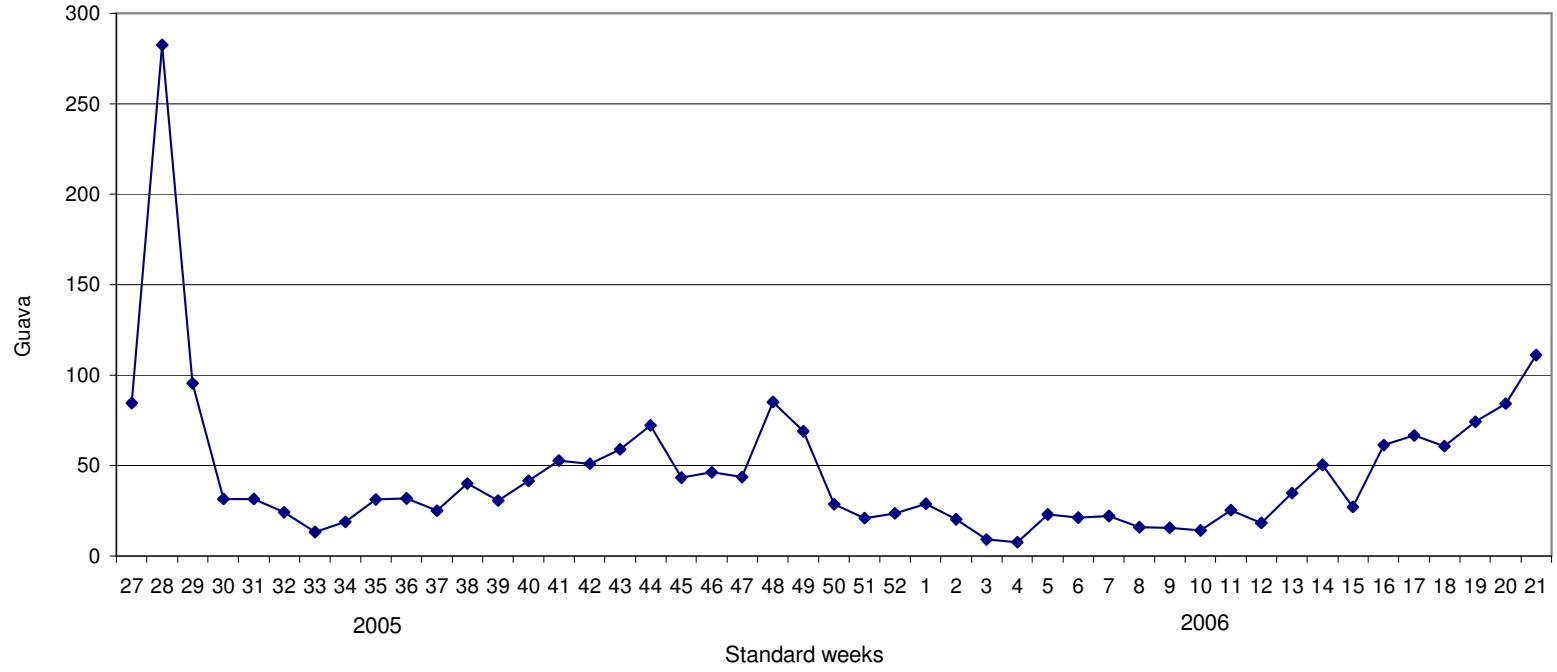

Fig. 7. Methyl eugenol trap catches of total fruit flies from July 2005 to May 2006 in guava orchard at UAS, Dharwad

Fig. 7. Methyl eugenol trap catches of total fruit files from July 2005 to May 2006 in guava orchard at UAS, Dharwad

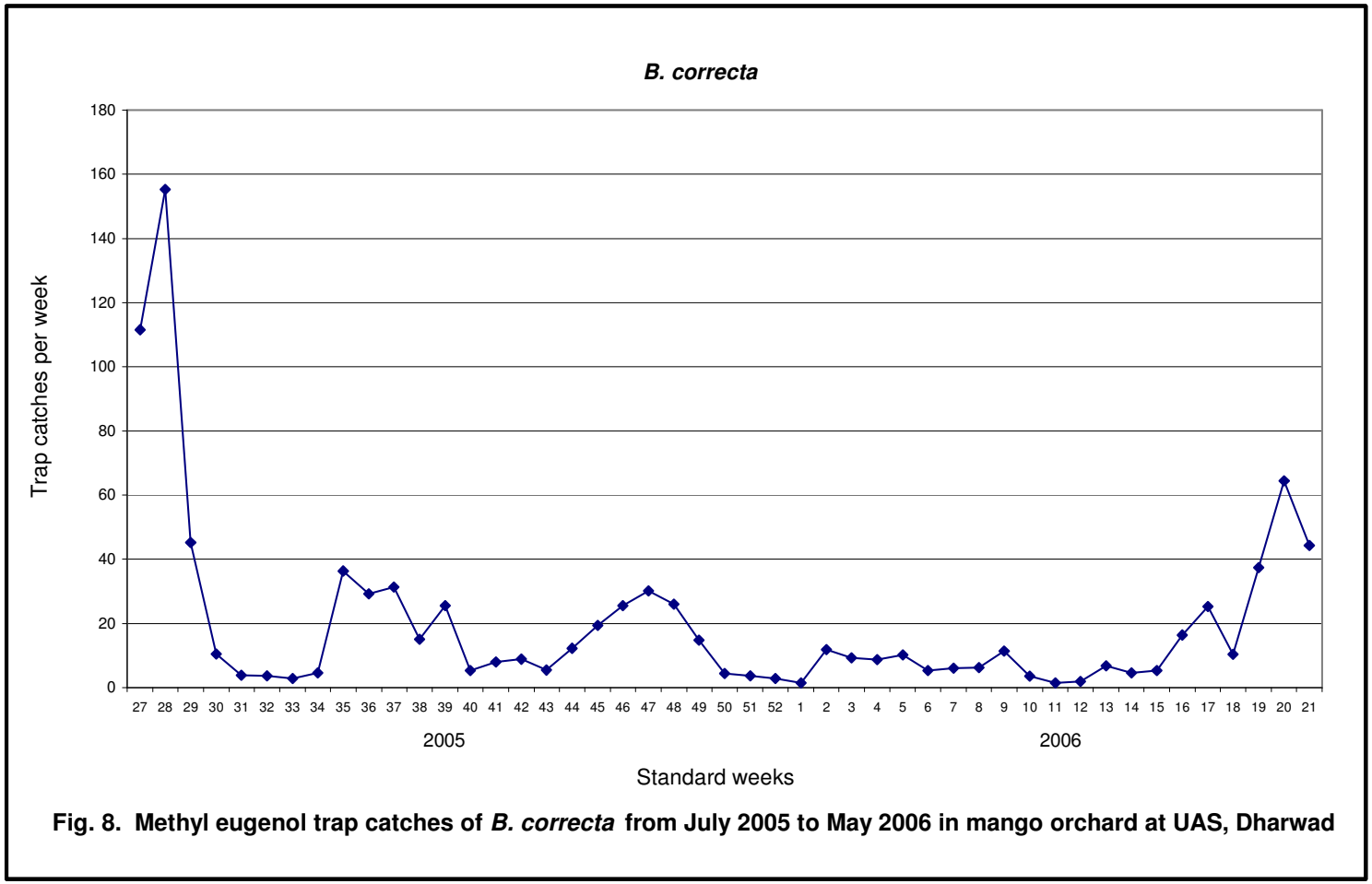

Fig. 8. Methyl eugenol trap catches of *B. correcta* from July 2005 to May 2006 in mango orchard at UAS, Dharwad

Fig. 8. Methyl eugenol trap catches of B. correcta from July 2005 to May 2006 in mango orchard at UAS, Dharwad

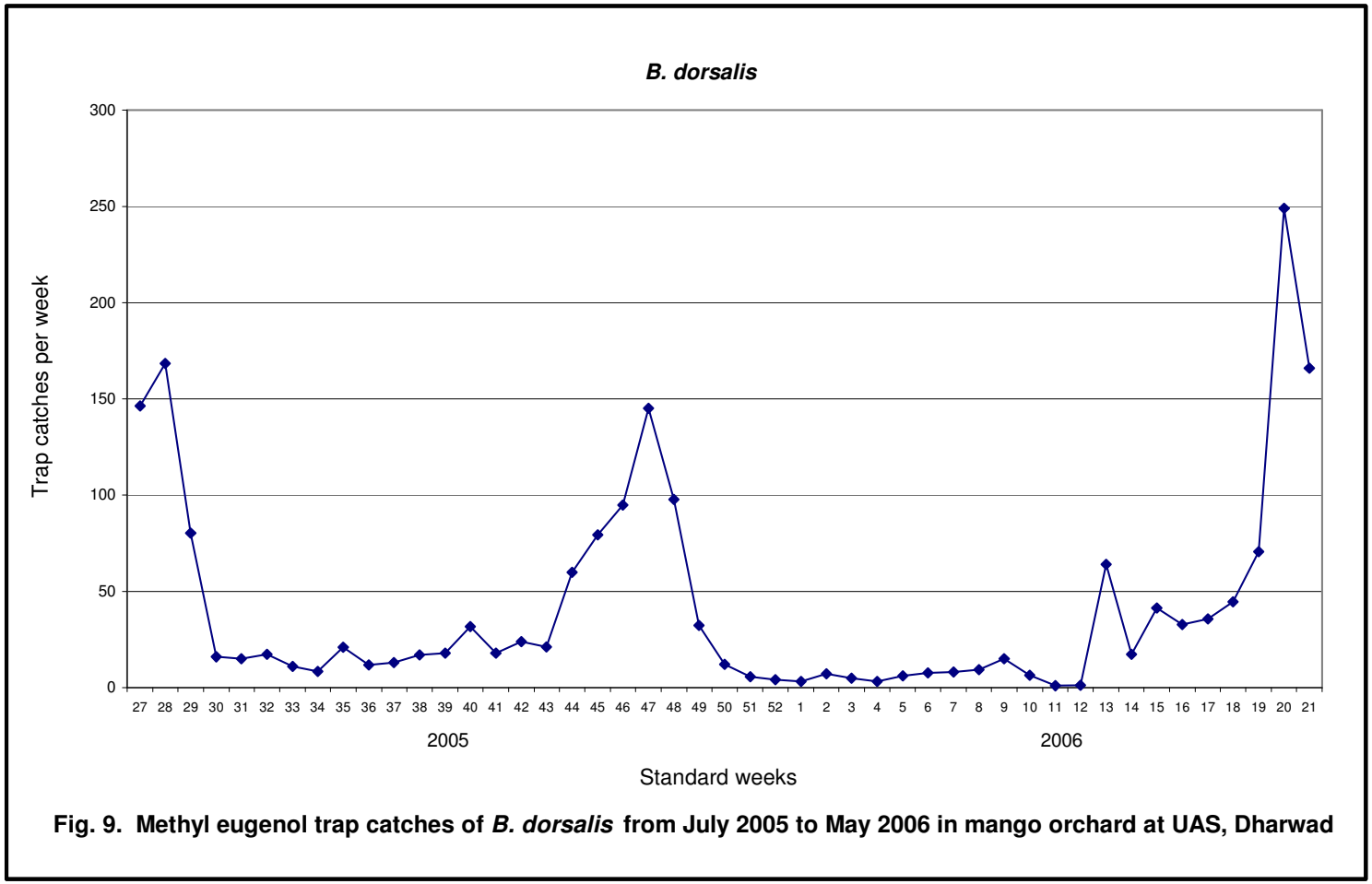

Fig. 9. Methyl eugenol trap catches of *B. dorsalis* from July 2005 to May 2006 in mango orchard at UAS, Dharwad

Fig. 9. Methyl eugenol trap catches of B. dorsalis from July 2005 to May 2006 in mango orchard at UAS, Dharwad

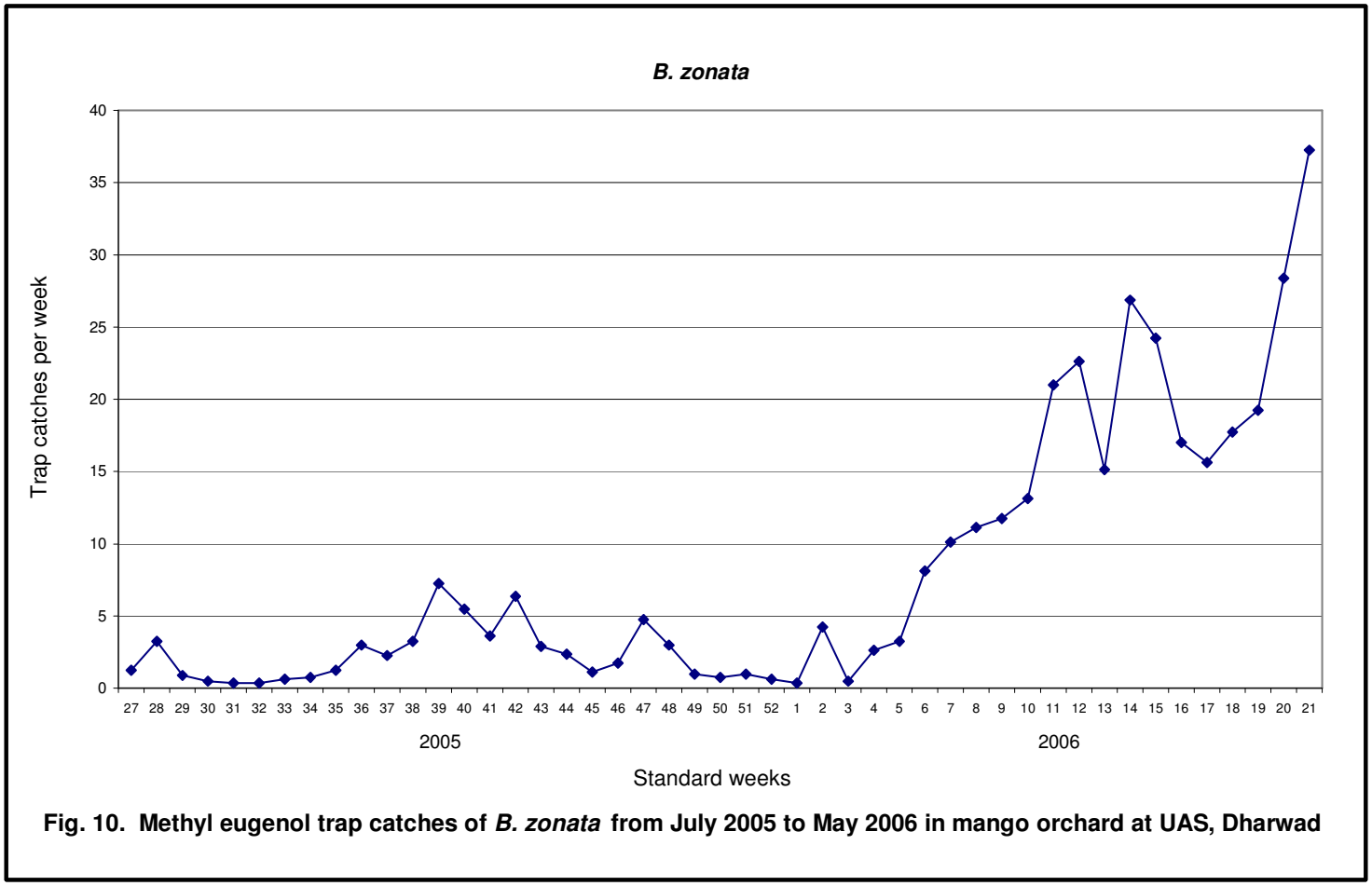

Fig. 10. Methyl eugenol trap catches of *B. zonata* from July 2005 to May 2006 in mango orchard at UAS, Dharwad

Fig. 10. Metthyl eugenol trap catches of B. zonata from July 2005 to May 2006 in mango orchard at UAS, Dharwad

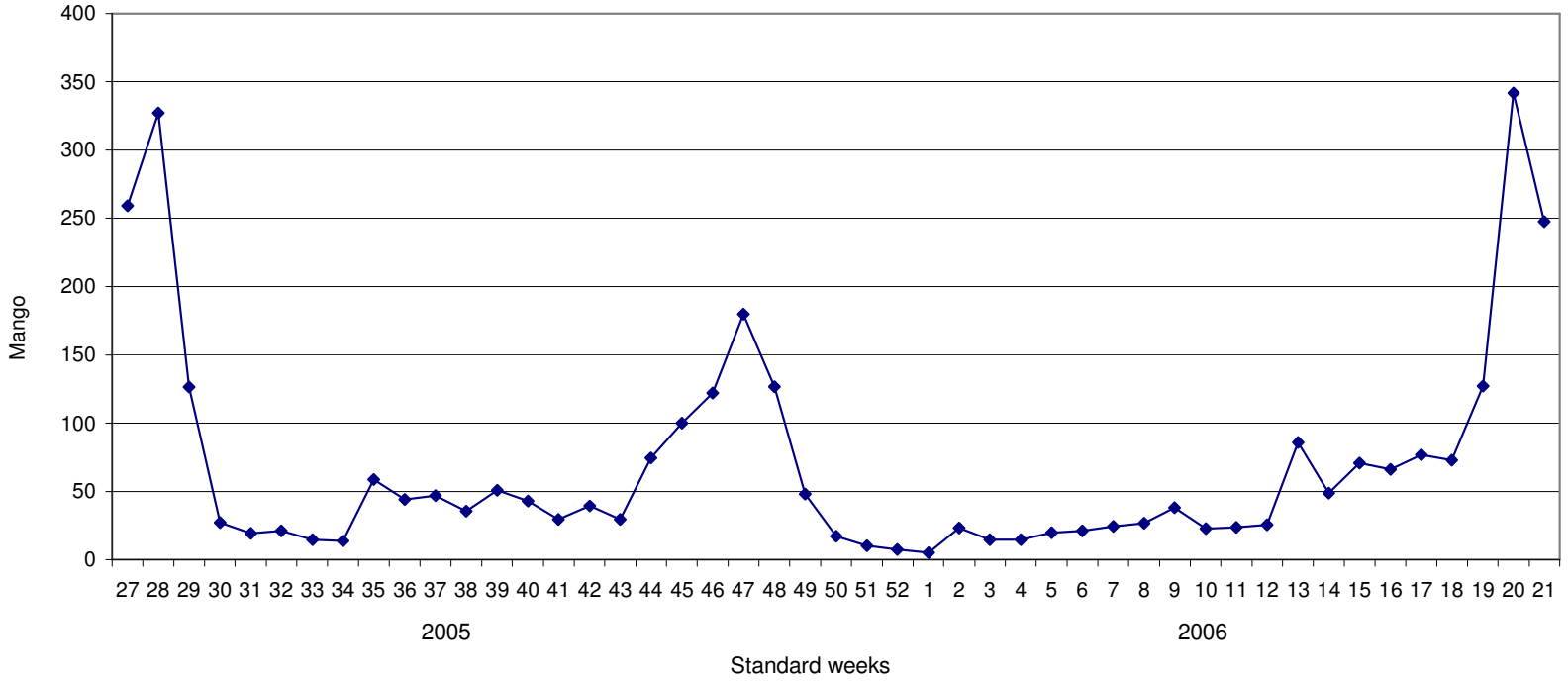

Fig. 11. Methyl eugenol trap catches of total fruit flies from July 2005 to May 2006 in mango orchard at UAS, Dharwad

Fig. 11. Methyl eugenol trap catches of total fruit files from July 2005 to May 2006 in mango orchard at UAS, Dharwad

These findings are in conformity with the reports of Suresh Babu and Viraktamath (2003) and Rajitha and Viraktamath (2006b) who reported peak trap catches of *B. correcta* during 23rd and 47th standard weeks.

In 2005, two major peaks of *B. dorsalis* were recorded during second week of July (168.50 fruit flies/trap/week) and third week of November (145.12 fruit flies/trap/week). In 2006, higher trapping was observed during fourth week of March and third week of May with mean trap catches of 64.12 and 49.00 fruit flies/trap/week (Fig. 9).

These results endorse the findings of Chiu and Chu (1986), Verghese and Sudhadevi (1998), Sushilkumar *et al*. (1999), Seewooruthun *et al*. (1999) and Ravikumar (2005).

However, Rajitha and Viraktamath (2006b) reported a major peak of *B. dorsalis* during 30th standard week and three minor peaks during 4th, 12th and 13th standard weeks.

The population of *B. zonata* peaked during last week of September in 2005 (Fig. 10). In 2006, the first major peak of 37.25 fruit flies/trap/week was observed during fourth week of May and another smaller peak during first week of April (26.87 fruit flies/trap/week). Similar trend was also reported by Agarwal and Kumar (1999b), Agarwal *et al*. (1999), Gupta and Bhatia (2000), Suresh Babu and Viraktamath (2003) and Ravikumar (2005).

However, Anjum *et al*. (2000) reported peak population during the first week of July. Rajitha and Viraktamath (2006b) reported four peaks during 42nd, 45th, 8th and 13th standard weeks at Dharwad.

When total fruit flies were considered irrespective of the species, two major peaks were observed during second week of July (327.12 fruit flies/trap/week) and third week of November (180.00 fruit flies/trap/week) in 2005, which were attributed to the peak fruiting of guava in the adjacent orchards. In 2006, two peaks were recorded during the last week of March (86.00 fruit flies/trap/week) and third week of May (341.75 fruit flies/trap/week) (Fig. 11). These peaks coincided with peak fruiting of mango in the orchard.

These results endorse the findings of Madhura (2001a), Sarada *et al*. (2001), Suresh Babu and Viraktamath (2003).

Present results are contrary to the findings of Rajitha and Viraktamath (2006b) who reported four peaks during 30th, 40th, 45th and 52nd standard week in 2003 and two small peaks during 3rd and 8th standard weeks in 2004.

The variations in the peaks of different species of fruit flies was obviously due to changes in the fruiting pattern in different places.

5.6 INFLUENCE OF WEATHER PARAMETERS ON TRAP CATCHES IN GUAVA AND MANGO ORCHARDS

5.6.1 Guava

In guava, trap catches of *B. correcta* had a significant positive correlation with minimum temperature (r=0.327*) (Table 13). Weather factors together influenced the trap catches to an extent of 12.3 per cent (Table 14).

These findings are in accordance with Jalaludidn *et al*. (2001) who observed the population of *B. correcta* having significant positive correlation with temperature. Viraktamath and Suresh Babu (2004) and Ravikmar (2005) also observed similar relationship. However, Rajitha and Viraktamath (2005a) did not find any relationship with weather parameters.

Trap catches of *B. dorsalis* had no relationship with weather parameters (Table 13). Present results are in contrary to the reports of Shukla and Prasad (1985) who observed a negative correlation between weekly rainfall and captures of *B. dorsalis*. Similarly Viraktamath and Suresh Babu (2004) and Ravikumar (2005) reported negative relation with morning

relative humidity. Rajitha and Viraktamath (2005a) found negative correlation with maximum temperature.

Trap catches of *B. zonata* also had no relation with weather parameters (Table 13). The present findings are in contrary with Agarwal and Kumar (1999b), Viraktamath and Suresh Babu (2004) and Rajitha and Viraktamath (2005a) who observed a high positive correlation with maximum temperature. Ravikumar (2005) also observed a highly significant positive correlation with maximum temperature.

5.6.2 Mango

B. correcta had high significant positive correlation with minimum temperature (r=0.324*) (Table 15). All the weather factors together had influence on the trap catches to an extent of 11.2 per cent (Table 16).

These results endorse the findings of Agarwal and Kumar (1999b), Suresh Babu and Viraktamath (2003) who observed a positive correlation with minimum temperature. Similarly Rajitha and Viraktamath (2006b) and Ravikumar (2005) reported a positive correlation with temperature.

There was no relationship between trap catches of *B. dorsalis* with weather parameters (Table 15). Present results are in contrary to the reports of Verghese and Sudha devi (1998) and Gupta and Bhatia (2000) who observed a positive correlation of *B. dorsalis* population with maximum and minimum temperature. Similarly Rajitha and Viraktamath (2006b) and Ravikumar (2005) obtained positive relation with minimum temperature.

The captures of *B. zonata* had a highly significant positive correlation with maximum temperature (r=0.815*) and negative correlation with afternoon relative humidity (r=-0.537**) and rainfall (r=-0.293*) (Table 15). All the other weather factors together had influence on the trap catches to an extent of 69.4 per cent (Table 16).

The results are in agreement with the reports of Agarwal and Kumar (1999b) and Suresh Babu and Viraktamath (2003). Similarly, Rajitha and Viraktamath (2006b) and Ravikumar (2005), found positive correlation with maximum temperature between trap catches with relative humidity and rainfall.

Varying results of the influence of weather parameters on trap catches of fruit flies have been reported both in guava and mango orchards. Chaudhary and Jamal (2000), Jalaluddin *et al*. (2001) and Sushilkumar *et al*. (1997) reported that the population of fruit flies coincided with ripening period of guava and mango fruits. Similarly, Shekarappa *et al*. (1998), Madhura (2001) and Suresh Babu and Viraktamath (2003) opined that availability of fruits influence the population fluctuation of fruit flies. Present results also endorse these views.

VI. SUMMARY

Results of the investigations carried out at Dharwad and Mummigatti from July 2005 to May 2006 on evaluation of different quantity of methyl eugenol and frequency of charging, efficacy of different colours and shapes of traps, evaluation of protein food baits against female fruit flies and monitoring and relationship between trap catches and weather parameter of fruit flies are summarized below.

The traps charged with 0.1 and 0.2 ml of methyl eugenol, attracted significantly more *B. correcta* and *B. dorsalis* in guava. In mango, the traps charged with 0.2 ml methyl eugenol were superior in attracting all the species. Pooled data in both the orchards indicated that more catches in the traps charged with 0.1 ml methyl eugenol in guava and 0.2 ml methyl eugenol in mango.

Experiment on the frequency of charging revealed that traps once charged with 0.1 ml methyl eugenol in guava and 0.2 ml methyl eugenol in mango could be run effectively upto four weeks in guava and three weeks in mango against *B. correcta.* In case of *B. dorsalis* charging at two weeks interval in guava and four weeks interval in mango proved effective. In *B. zonata,* the traps were effective upto three weeks.

Yellow and transparent traps attracted significantly high number of *B. correcta* in guava and mango, respectively. Green and orange coloured traps in guava, black coloured traps in mango were efficient against *B. dorsalis*, *B. zonata* was attracted to red coloured traps in mango ecosystem. Pooled data revealed that yellow colour traps were efficient in guava and black colour traps in mango.

Among various shapes of traps, bottles and cylinders in guava and bottles in mango were efficient against *B. correcta. B. dorsalis* preferred cylinders and spheres in guava and mango respectively. In mango, *B. zonata* had equal preference to bottles, cylinders, spheres and Del-Ta trap. When the total fruit flies were considered, cylinders and bottles in guava and bottles in mango were efficient.

Among various protein baits, fruit fly diet, mango pulp with ammonium acetate combination attracted significantly more number of female fruit flies when considered either species-wise or total fruit flies.

Monitoring studies revealed occurrence of *B. dorsalis*, *B. correcta*, and *B. zonata* throughout the year. In guava *B. correcta* had four peak catches during second week of July, second week of October in 2005 and second week of January and fourth week of May in 2006 (255.38, 26.75, 15.13 and 74.63, fruit flies/trap/week) respectively. *B. dorsalis* had three peaks during third week of July, fourth week of October and fourth week of November (31.50, 44.88 and 66.38 fruit flies/trap/week respectively) in 2005. In 2006, one major peak was observed during first week of April (44.00 fruit flies/trap/week).

B. zonata had two peaks during second week of July (16.88 fruit flies/trap/week), fourth week of October (6.75 fruit flies/trap/week) in 2005 and one peak during second week of March in 2006 (6.50 fruit flies/trap/week). When total number of fruit flies was considered, two peaks were observed during second week of July (282.63 fruit flies/trap/week) and fourth week of November (85.25 fruit flies/trap/week) in 2005. In 2006 one major peak was observed during fourth week of May (111.00 fruit flies/trap/week).

In mango, *B. correcta* had two peaks during second week of July (155.37 fruit flies/trap/week) and third week of November (30.13 fruit flies/trap/week) in 2005. In 2006, a major peak was observed during third week of May (64.37 fruit flies/trap/week). *B. dorsalis* had two peaks during second week of July and third week of November in 2005 (168.50 and 145.13 fruit flies/trap/week). In 2006 two peaks occurred during fourth week of March (64.12 fruit flies/trap/week) and third week of May (49.00 fruit flies/trap/week).

B. zonata had one major peak during fourth week of September (7.25 fruit flies/trap/week) in 2005. In 2006 the first minor peak was observed in the first week of April and a major peak in the fourth week of May (26.88, 37.25 fruit flies/trap/week).

When total fruit flies were considered highest peak occurred during second week of July with 327.12 fruit flies/trap/week in 2005. In 2006 two peaks were recorded during fourth week of March and third week of May (327.12 and 180.00 fruit files/trap/week).

In guava, trap catches had high significant positive correlation with minimum temperature (r=0.327*) while other parameters had no relationship. *B. dorsalis* and *B. zonata* had no relation with weather parameters.

In mango, there was highly significant positive correlation with minimum temperature (r=0.324*) and trap catches of *B. correcta* and *B. dorsalis* had no relation with weather parameters. *B. zonata* had high significant positive correlation with maximum temperature (r=0.815*) and negative correlation with after noon relative humidity (r=-0.537) and rainfall (r=0.293). Overall influence of weather parameters on trap catches of *B. zonata* was to the extent of 69.40 fruit flies/trap/week.

VII. REFERENCES

AGARWAL, M.L. AND KUMAR, P., 1999a, Relative efficacy of bait and attractant combinations against peach fruit fly, *Bactrocera zonata* (Saunders). *Pestology*, **23**: 23-26.

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

AGARWAL, M.L., KUMAR, P. AND KUMAR, V., 1999, Population suppression of *Bactrocera dorsalis* (Hendel) by *Bactrocera zonata* (Saunders) (Diptera : Tephritidae) in North Bihar. *Shashpa*, **6**: 189-191.

AGARWAL, M.L., RAHMAN, S., SINGH, S.P.N. AND YAZDANI, S.S., 1995, Weather conditions and population dynamics of *Bactrocera dorsalis*. *Journal of Research,* Birsa Agricultural University, **7**: 149-151.

ALYOKHIN, V.A., MESSING, R.H. AND DUAN, J.J., 2000, Visual and olfactory stimuli and fruit maturity affect trap capture of oriental fruit flies (Diptera : Tephritidae). *Journal of Economic Entomology*, **93**: 644-649.

ANJUM, S., RAZAQ, M. AND YAZDANI, S.S., 2000, Studies on seasonal activity and control of fruit flies (*Dacus* spp.) on mango (*Mangifera indica* L.) at Faisalabad, Pakistan. *Arab Journal of Plant Protection*, **18**: 121-123.

ANONYMOUS, 2004a, *Indian Agriculture*. Indian Economic Data Research Centre, New Delhi, pp.244-252.

ANONYMOUS, 2004b, *Package of Practices for a Horticultural Crops*, University of Agricultural Sciences, Dharwad, p.470.

BAGLE, B.G. AND PRASAD, V.G., 1983, Effect of weather parameters on population dynamics of oriental fruit fly, *Dacus dorsalis* Hendel. *Journal of Entomological Research*, **7**: 95-98.

BAKRI, A., HADIS, H., EPSKY, N.D., HEATH, R.R. AND HENDRICHS, J., 1998, Female *Ceratitis capitata* (Diptera : Tephritidae) capture in a dry trap baited with a food based synthetic attractant in an argan forest in Morocco. Part I. Low population field test. *Canadian Entomologist*, **130**: 349-356.

BALASUBRAMANIAM, G., ABRAHAM, E.V., VIJAYARAGHAVAN, S., SUBRAMANIAM, T.R., SANTHANARAMAN, T. AND GUNASEKARAN, C.R., 1972, Use of male annihilation technique in the control of the oriental fruit fly, *Dacus dorsalis* Hendel. *Indian Journal of Agricultural Science*, **42**: 975-977.

BELAVADI, V.V., 1979, Bionomics of the oriental fruit fly, *Dacus dorsalis* Hendel. (Diptera : Tephritidae) on guava (*Psidium guajava* L.) and its control by male annihilation. *M.Sc.(Agri.) Thesis*, University of Agricultural Sciences, Bangalore, p.95.

BOLLER, E.F., 1969, Neuw uber die kirschenfliege : Frieiland veruche im Jahre 1969. *Schweizerische Zeitschrift Fur Obst Und Weinbau*, **105**: 566-572.

BOSCAN DE MARTINEZ, N., VALLE, A. AND GODOY, F., 2001, Fruit fly attractants in mango plantations located in Maracay, Venezuela. *Agronomia Tropical Maracay*, **51**: 259-267.

BRESSAN, S., TELES, M.M.C.DA. AND CARVAJAL, S.S.R., 1991, Attractiveness of different trap colours and forms for the fruit fly, *Anastrepha* spp. (Diptera : Tephritidae) in a field test. *Anais da Sociedade Entomologica do Brasil*, **20**: 17-26.

BROUGHTON, S. AND FRANCIS DE LIMA, C.P., 2002, Field evaluation of female attractants for monitoring *Ceratitis capitata* (Diptera : Tephritidae) under a range of climatic conditions and population levels in Western Australia. *Journal of Economic Entomology*, **95**: 507-512.

CHAUDHARY, M.M.K. AND JAMAL, Q., 2000, Effect of abiotic factors on population fluctuation of oriental and peach fruit flies at Rawalpindi, Pakistan. *Pakistan Journal of Zoology*, **32**: 182-185.

CHEN, H.D., ZHOU, C.Q., YANG, P.J. AND LIANG, G.Q., 1995, On the seasonal population dynamics of melon and oriental fruit flies and pumpkin fly in Guangzhou area. *Acta Phytophylacica Sinicia*, **22**: 348-354.

CHIU, H.T. AND CHU, Y.T., 1986, The occurrence and injury of the oriental fruit fly in the southern Taiwan. *Plant Protection Bulletin*, Taiwan, **28**: 313-321.

CHRISTENSON, L.E. AND FOOTE, R.E., 1960, Biology of fruit flies. *Annual Review of Entomology*, **5**: 171-192.

CIRIO, U., 1972, Osservazioni sul compartmento di ovideposozine delle *Rhagoletis completa* Cresson (Diptera: tephritidae) in labotaroie. In *Alti del IX Congresso Itlaiano di Entomologie Seina,* 20-25 Guingno, pp.99-172.

CLARKE, A.R., ALLWOOD, A., CHINAJARIYAWONG, A., DREW, R.A.I., HENGSAWAD, C., JIRASURAT, M., KRONG, C.K., KRITSANEEPAIBOON, S. AND VIJAYSEGARAN, S., 2001, Seasonal abundance and host use patterns of seven *Bactrocera* Macquart species (Diptera : Tephritidae) in Thailand and Peninsular, Malaysia. *Raffles Bulletin of Zoology,* **49**: 207-220.

CORNELIUS, M.L., DUAN, J.J. AND MESSING, R.H., 1999, Visual stimuli and the response of female oriental fruit flies (Diptera : Tephritidae) to fruit-mimicking traps. *Journal of Economic Entomology*, **92**: 121-129.

CORNELIUS, M.L., DUAN, J.J. AND MESSING, R.H., 2000a, Volatile host fruit odors as attractants for the oriental fruit fly (Diptera : Tephritidae). *Journal of Economic Entomology*, **93**: 93-100.

CORNELIUS, M.L., NERGEL, L., DUAN, J.J. AND MESSING, R.H., 2000b, Responses of female oriental fruit flies (Diptera : Tephritidae) to protein and host fruit odours in field cage and open field tests. *Environmental Entomology*, **29**: 14-19.

CUNNINGHAM, R.T., CHAMBERS, D.L., FORBES, A.G., 1975, Oriental fruit fly : Thickened formulation of methyl eugenol in spot application for male annihilation. *Journal of Economic Entomology*, **68**: 861-863.

CUNNINGHAM, R.T., 1989, Male annihilation. In *World Crop Pests*, Eds. Robinson, A.S. and Hooper, G. Elsevier, Amsterdam, The Netherlands.

DREW, R.A.I., 1974, The response of fruit fly species (Dipetera : Tephritidae) in the south pacific area to male attractants. *Journal Australian Entomology Society*, **13**: 267-270.

DREW, R.A.I., 1989, The topical fruit flies (Diptera : tephritidae) in Australian and oceanic region. *Memoirs of the Queensland Museum*, **26**: p.521.

DREW, R.A.I. AND HANCOCK, D.L., 1994, The *Bactrocera dorsalis* complex of fruit flies (Diptera : Tephritidae : Dacinae) in Asia. *Bulletin of Entomology Research and Supplement*, **2**: 1-68.

DREW, R.A.I., HOOPER, G.H.S. AND BATEMAN, M.A., 1982, The economic fruit flies of south pacific region, p.139.

DWIVEDI, S.C., KULDEEP, SINGH, S.M. AND KATIYAR, R.R., 2003, Seasonal incidence of insect pests associated with mango crop. *Annals of Plant Protection Sciences*, **11**: 159-160.

ECONOMOPOULOS, A., 1989, Use of traps based on colour and/or shape. In : *World Crop Pests, Fruit flies : Their Biology, Natural Enemies and Control*. Eds. Robinson A.S. and Hopper, G., Elsevier, Amsterdam, **3**: 315-327.

EPSKY, N.D. AND HEATH, R.R., 1998, Exploiting the interaction of chemical and visual cues in behavioral control measures for pest tephritid fruit flies. *Florida Entomologist*, **81**: 273-282.

EPSKY, N.D., HEATH, R.R., GUZMAN, A. AND MEYER, W.L., 1995, Visual cue and chemical cue interactions in a dry trap with food-based synthetic attractant for *Ceratitis capitata* and *Anastrepha ludens* (Diptera : Tephritidae). *Environmental Entomology*, **24**: 1387-1395.

EPSKY, N.D., HEATH, R.R., UCHIDA, G., RIZZO, J., VARGAS, R.I. AND JERONIMO, F., 1996, Capture of Mediterranean fruit flies (Diptera : Tephritidae) using color inserts in trimedlure-baited Jackson traps. *Environmental Entomology*, **25**: 256-260.

EPSKY, N.D., HENDRICHS, J., KATSOYANNOS, B.I., VASQUEZ, L.A., ROS, J.P., ZUMREOGLU, A., PEREIRA, R., BAKRI, A., SEEWOORUTHUN, S.I. AND HEATH, R.R., 1999, Field evaluation of female-targeted trapping systems for *Ceratitis capitata* (Diptera : Tephritidae) in seven countries. *Journal of Economic Entomology*, **92**: 156-164.

FABRE, F., RYCKEWAERT, P., DUYCK, P.F., CHIROLEU, F. AND QUILICI, S., 2003, Comparison of the efficacy of different food attractants and their concentration for melon fly (Diptera : Tephritidae). *Journal of Economic Entomology*, **96**: 231-238.

FLETCHER, B.S. AND PROKOPY, R.J., 1991, Host location oviposition in tephritid fruit flies. In *Reproductive behaviour of Insects : Individuals and Populations*. Chapman and Hall, London, pp.139-171.

GAZIT, Y., ROESSLER, Y., EPSKY, N.D. AND HEATH, R.R., 1998, Trapping females of the Mediterranean fruit fly (Diptera : Tephritidae) in Israel : Comparison of lures and trap types. *Journal of Economic Entomology*, **91**: 1355-1359.

GREANY, P.D., AGEE, H.R., BURDITT, A.K.Jr. AND CHAMBERS, D.L., 1977, Field studies on colour preferences of the Caribbean fruit fly, *Anastrepha suspensa* (Diptera : Tephritidae), by use of fluorescent colours. *Entomologia Experimentalis et Applicata,* **23**: 20-25.

GREANY, P.D. AND SZENTES, I.A., 1979, Oviposition behaviour of laboratory reared and wild Caribbean fruit flies *Anastrepha suspensa* (Diptera : Tephritidae) : II selected physical influences. *Entomology Experiment and Application*, **26**: 239-244.

GUPTA, D. AND BHATIA, R., 2000, Population fluctuations of fruit flies, *Bactrocera* spp. in submountainous mango and guava orchards. *Journal of Applied Horticulture,* Lucknow, **2**: 47-49.

GURNEY, W.B., 1925, The control of fruit fly. In *Agricultural Gazette of New South Wales* December, 1995, Sydney, pp.1-9.

HEATH, R.R., EPSKY, N.D., DUEBEN, B.D. AND MEYER, W.L., 1996, Systems to monitor and suppress Mediterranean fruit fly (Diptera : Tephritidae) populations. *Florida Entomologist*, **79**: 144-153.

HEATH, R.R., EPSKY, N.D., GUZMAN, A., DUEBEN, B.D., MANUKIAN, A. AND MEYER, W.L., 1995, Development of a dry plastic insect trap with food based synthetic attractant for the Mediterranean and the Mexican fruit flies (Diptera : Tephritidae). *Journal of Economic Entomology*, **88**: 1307-1315.

HWANG, Y.B., KAO, C.H. AND CHENG, E.Y., 1997, The monitoring and control of the oriental fruit fly in Taiwan. *Plant Protection Bulletin Taipei*, **39**: 125-136.

JALALUDDIN, S.M., NATARAJAN, K. AND SADAKATHULLA, S., 2001, Population fluctuation of the guava fruit fly, *Bactrocera correcta* (Bezzi) in relation to hosts and abiotic factors. *Journal of Experimental Zoology*, India, **4**: 323-327.

JALALUDDIN, S.M., NATARAJAN, K., SADAKATHULLA, S. AND BALASUBRAMANIAN, S., 1999, Discovery of the guava fruit fly *Bactrocera correcta* (Bezzi). *Entomon*, **24**: 195-196.

JALALUDDIN, S.M., NATARAJAN, K., SADAKATHULLA, S. AND RAJUKKANNU, K., 1998, Effect of colour, height and dispenser on catches of guava fruit fly. In *Proceedings of I National Symposium on Pest Management in Horticulture Crops*, Bangalore, pp.34-39.

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

KATSOYANNOS, B.I., 1989, Field responses of Mediterranean fruit flies to spheres of different color patterns and to yellow crossed panels. In : *Fruit flies of Economic Importance*, Ed. Cavalloro R., Balkema, Rome, Italy, pp.393-400.

KATSOYANNOS, B.I. AND KOULOUSSIS, N.A., 2001, Captures of the olive fruit fly *Bactrocera oleae* on spheres of different colours. *Entomologia Experimentalis et Applicata*, **100**: 165-172.

KATSOYANNOS, B.I. AND PAPADOPOULOS, N.T., 2004, Evaluation of synthetic female attractants against *Ceratitis capitata* (Diptera : Tephritidae) in sticky coated spheres and McPhail type traps. *Journal of Economic Entomology*, **97**: 21-26.

LAKSHMANAN, P.L., BALASUBRAMANIAM, G. AND SUBRAMANIAM, T.R., 1973, Effect of methyl eugenol in the control of the oriental fruit fly, *Dacus dorsalis* Hendel on mango. *Madras Agricultural Journal,* **60**: 628-629.

LIBURD, O.E., ALM, S.R., CASAGRANDE, R.A. AND POLAVARAPU, S., 1998, Effect of trap colour, bait, shape and orientation in attraction of blueberry maggot (Diptera : Tephritidae) flies. *Journal of Economic Entomology*, **91**: 243-249.

LIBURD, O.E., POLAVARAPU, S., ALM, S.R. AND CASAGRANDE, R.A., 2000, Effect of trap size, placement and age on captures of blueberry maggot flies (Diptera:Tephritidae). *Journal of Economic Entomology,* **93**: 1452-1458.

LIU, Y.C., 1991, Development of attractants for controlling the melon fly *Dacus cucurbitae* Coquillet in Taiwan. *Chinese Journal of Entomology*, Special Publication **1**(4): 115-129.

LIU, Y.C. AND LIN, J.S., 1992, The attractiveness of 10% MC to melon fly *Dacus cucurbitae* Coquillet. *Plant Protection Bulletin Taipei*, **34**(4): 307-315.

LIU, Y.C., CHI, H. AND CHEN, S.H., 1985, The population fluctuation of the oriental fruit fly, *Dacus dorsalis* Hendel in Chia-Yi Orchard. *Chinese Journal of Entomology*, **5**: 79-84.

MADHURA, H.S., 2001, Management of fruit flies (Diptera : Tephritidae) using physical and chemical attractants. *M.Sc.(Agri.) Thesis*, University of Agricultural Sciences, Bangalore, p.80.

MADHURA, H.S. AND VIRAKTAMATH, C.A., 2003, Efficacy of different traps in attracting fruit flies (Diptera : Tephritidae). *Pest Management in Horticultural Ecosystems*, **9**: 153-154.

MAKHMOOR, H.D. AND SINGH, S.T., 1998, Effective concentration of methyl eugenol for the control of guava fruit fly *Dacus dorsalis* Hendel in guava orchard. *Annals of Plant Protection Science*, **6**: 165-169.

MANN, G.S., 1996, Seasonal incidence and build up of *Bactrocera dorsalis* Hendel on mango in Punjab. *Journal of Insect Science*, **9**: 129-132.

MAYER, D.F., LONG, L.E., SMITH, T.J., OLSEN, J., RIEDEL, H., HEATH, R.R., LESKEY, T.C. AND PROKOPY, R.J., 2000, Attraction of adult *Rhagoletis indifferens* (Diptera : Tephritidae) to unbaited and odour baited red spheres and yellow rectangles. *Journal of Economic Entomology*, **93**: 347-351.

MAZOR, M., PEYSAKHIS, A. AND REUVEN, G., 2002, Release rate of ammonia – a key component in the attraction of female Mediterranean fruit fly to protein-based food lures. *International Organization for Biological and Integrated Control of Noxious Animals and Plants Bulletin*, **25**: 1-6.

NAKAGAWA, S., PROKOPY, R.J., WONG, T.T.Y., ZIEGLER, J.R., MITCHELL, S.M., URAGO, T. AND HARRIS, E.J., 1978, Visual orientation of *Ceratitis capitata* flies to fruit models. *Entomologia Experimentalis et Applicata*., **24**: 193-198.

NARAYANAN, E.S. AND BATRA, H.N., 1960, *Fruit flies and their Control*. Indian Council of Agricultural Research, New Delhi, p.68.

OATMAN, E.R., 1964, Apple maggot trap and attractant studies. *Journal of Economic Entomology*, **54**(4): 529-531.

PRASAD, V.G. AND BAGLE, B.G., 1978, Studies on the population dynamics of oriental fruit fly, *Dacus dorsalis* Hendel by male annihilation technique. *Paper Presented at the All India Workshop on Population Ecology in Relation to Insects of Economic Importance*. Jan 18-20, Bangalore.

PROKOPY, R.J., 1966, Artificial ovipositional devices for apple maggot. *Journal of Economy Entomology,* **59**(4): 231-232.

PROKOPY, R.J., 1968a, Visual responses of apple maggot flies, *Rhagoletis pomonella* (Diptera : Tephritidae) : Orchard studies. *Entomologia Experimentalis et Applicata*., **11**: 403-422.

PROKOPY, R.J., 1968b, Influence of photo period, temperature and food on initiation of diapause in the apples maggot. *Canadian Entomology*, **100**: 318-329.

PROKOPY, R.J., 1973, Dark enamel sphere capture as many apple maggot flies as fluorescent spheres. *Environmental Entomology*, **2**: 953-954.

PROKOPY, R.J., 1977, Attraction of *Rhagoletis* flies (Diptera : Tephritidae) to red spheres of different sizes. *Canadian Entomologist*, **109**: 593-596.

PROKOPY, R.J. AND BOLLER, E.F., 1971, Response of European cherry fruit flies to coloured rectangles. *Journal of Economical Entomology*, **63**(6): 1413-1417.

PROKOPY, R.J. AND COLI, W.M., 1978, Selective traps for monitoring *Rhagoletis mendax* flies. *Protection Ecology*, **1**: 45-53.

PROKOPY, R.J. AND ECONOMOPOULOS, A.P., 1976, Colour response of *Ceratitis capitata* flies. *Zeitschraft fiir Angewandte Entomologie*, **80**: 434-437.

PROKOPY, R.J. AND OWENS, E.D., 1983, Visual detection of plants by herbivorous insects. *Annual Review of Entomology*, **28**: 329-364.

PUTRUELE, G., ABBIATI, N.N. AND VACCARO, N.C., 1993, Soyabean protein hydrolysate bait for medfly control. In *Fruit Flies*, *Biology and Management*, Eds. Martin Aluja and Pablo Liedo, Springer-Verlag Publications, New York, pp.369-374.

RAHMAN, S.J., 1990, Ecology and management of *Dacus dorsalis* Hendel and Dacus cucurbitae Coquillet. *Ph.D. Thesis,* G. B. Pant University of Agriculture and Technology, Pantnagar, p.224.

RAHMAN, O., RAHMAN, S. AND AGARWAL, M.L., 1995, Guarding against oriental fruit fly, *Bactrocera dorsalis* by the use of biotechnical control. *Indian Horticulture*, **39**: 13-15.

RAJITHA, A.R. AND VIRAKTAMATH, S., 2005a, Efficiency of different types of traps in attracting fruit flies in guava orchard at Dharwad, Karnataka . *Pest Management and Economic Zoology*, **13**: 111-120.

RAJITHA, A.R. AND VIRAKTAMATH, S., 2005b, Response of fruit flies to different types of traps in mango orchard. *Pest Management in Horticultural Ecosystem*, **11**: 15-25.

RAJITHA, A.R. AND VIRAKTAMATH, S., 2005c, Evaluation of protein food baits in attracting female fruits flies in guava and mango orchards. *Pest Management in Horticultural Ecosystems*, **11**: 1-5.

RAJITHA, A.R. AND VIRAKTAMATH, S., 2005d, Species diversity and relative abundance of fruit flies (Diptera : Tephritidae) in guava and mango orchards at Dharwad. Paper presented at *National Conference on Animal Taxonomy – Emerging Trends*, Kochi January 14-15, 2005.

RAJITHA, A.R. AND VIRAKTAMATH, S., 2006a, Monitoring fruit flies (Diptera : Tephritidae) in guava orchard in Dharwad, Karnataka. *Karnataka Journal of Agricultural Sciences*, **19**: 35-39.

RAJITHA, A.R. AND VIRAKTAMATH, S., 2006b, Investigations on the population dynamics of fruits flies in mango orchard at Dharwad. *Karnataka Journal of Agricultural Sciences*, **19**: 134-137.

RAMANI, S., 1997, Biosystematic studies on fruit flies (Diptera: Tephritidae) with special reference to the fauna of Karnataka and Andaman and Nicobar. *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore, p.214.

RAVIKUMAR, CH., 2005, Studies on fruit flies in guava and mango orchards with special reference to their management through mass trapping. *M.Sc.(Agri.) Thesis*, University of Agricultural Sciences, Dharwad, p.90.

REISSIG, W.C., 1976, Comparison of traps and lures for *Rhagoletis fausta* and *R. cingulata*. *Journal of Economic Entomology*, **69**(5): 639-643.

ROBACKER, D.C., 1992, Effects of shape and size of coloured traps on attractiveness to irradiated, laboratory-strain Mexican fruit flies (Diptera : Tephritidae). *Florida Entomologist*, **75**: 230-241.

ROBACKER, D.C. AND HEATH, R.R., 2001, Easy to handle sticky trap for fruit flies (Diptera : Tephritidae). *Florida Entomologist*, **84**: 302-304.

ROBACKER, D.C., MORENO, D.S. AND WOLFENBARGER, D.A., 1990, Effects of trap colour, height and placement around trees on capture of Mexican fruit flies (Diptera : Tephritidae). *Journal of Economic Entomology,* **83**: 412-419.

ROBACKER, D.C. AND WARFIELD, W.C., 1993, Attraction of both sexes of Mexican fruit fly, *Anastrepha ludens*, to a mixture of ammonia, methylamine and putrescine. *Journal of Chemical Ecology*, **19**: 2999-3016.

ROOMI, M.W., ABBAS, T., SHAH, A.H., ROBINA, S., QURESHI, A.A., SAIN, S.S. AND NASIR, K.A., 1993, Control of fruit flies (*Dacus* sp.) by attractants of plant origin. *Anzeiger fiir Schadlingskunde*, *Pflanzeschutz, Umwelschutz*, **66**: 155-157.

SANDERS, W., 1962, Das verhalten der mitellmeerfruchtfliege *Ceratitis capitata* Weid, beider Eialblage. *Zeitschrift fur Teirpsychologie*, **19**(1): 1-28.

SAR, S., BALAGAWI, S., MARARUAI, A. AND PUTULAN, D., 2001, Fruit fly Research and Development in Papua New Guinea. *Report of Regional Fruit fly Project*, pp.571-574.

SARADA, G., MAHESWARI, T.U. AND PURUSHOTHAM, K., 2001a, Effect of trap colour, height and placement around trees in capture of mango fruit flies. *Journal of Applied Zoological Researches*, **12**: 108-110.

SARADA, G., MAHESWARI, T.U. AND PURUSHOTHAM, K., 2001b, Seasonal incidence and population fluctuation of fruit flies in mango and guava. *Indian Journal of Entomology*, **63**: 272-276.

SATPATHY, S. AND SAMARJIT RAI, 2002, Luring ability of indigenous food baits for fruit fly, *Bactrocera cucurbitae* (Coq.). *Journal of Entomological Research*, **26**: 249-252.

SEEWOORUTHUN, S.I., SOOKAR, P., PERMALLOO, S., JOOMAYE, A., ALLECK, M., GUNGAH, B. AND SOONNOO, A.R., 2001, An attempt at the eradication of the oriental fruit fly, *Bactrocera dorsalis* (Hendel) from Mauritius. *Annual Report of the*

Agricultural Services of the Ministry of Agriculture, Fisheries and Co-operatives, pp.1-10.

SHEKARAPPA, VIRAKTAMATH, S.A., PATIL, B.V. AND YELSHETTY, S., 1998, Influence of weather parameters on the pheromone trap catches of fruit flies. In *Proceedings of First National Symposium on Integrated Pest Management in Horticultural Crops*, Bangalore, p.27.

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. *Tropical Pest Management*, **31**: 273-275.

SIKHAMANY, S.D. AND MURTI, G.S.R., 2005, Needed: Shift in Policies. In *The Hindu Survey of Indian Agriculture*, Eds. N. Ram, National Press, Kasturi Buildings, Chennai, pp.143-146.

SINGH, S.P., 1993, Integrated pest management in horticultural crops. *Indian Horticulture*, **38**: 25-40.

SIVINSKI, J., 1990, Coloured spherical traps for capture of Caribbean fruit fly, *Anastrepha suspensa*. *Florida Entomologist*, **73**: 123-128.

SMITH, R.F., MAZEROLLE, M., ESTABROOKS, E. AND VINCENT, C., 2001, Monitoring apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera : Tephritidae) populations in commercial apple orchards of Nova Scotia, New Brunswick and Quebec. *Technical Report, Atlantic Food and Horticulture Research Centre*, pp.1-12.

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. *Journal of Hill Research*, **11**: 171-177.

SOUNDARRAJAN, K., DHANDAPANI, N. AND CHEZHIYAN, N., 1996, A low cost technology to control fruit fly *Dacus cucurbitae* coq of chow-chow. *Pestology*, **20**(7): 15-16.

STARK, J.D. AND VARGAS, R.I., 1992, Differential response of male oriental fruit fly (Diptera : Tephritidae) to coloured traps baited with methyl eugenol. *Journal of Economic Entomology*, **85**: 802-812.

STEINER, L.F., 1952, Fruit fly control in Hawaii with poison-bait sprays containing protein hydrolysates. *Journal of Economic Entomology*, **45**: 838-843.

STONEHOUSE, J., 2001, An overview of fruit fly research knowledge and needs in the Indian Ocean region. In: *Proceedings of the Second National Symposium on Integrated Pest Management (IPM) in Horticultural Crops* : *New Molecules, Biopesticides and Environment*, Bangalore, pp.21-23.

SUNANDITA AND GUPTA, D., 2001, Testing of boric acid and protein hydrolysate bait mixture against fruit fly, *Bactrocera tau* Walker. *Indian Journal of Entomology*, **63**: 125-129.

SURESH BABU, K. AND VIRAKTAMATH, S., 2003, Species diversity and population dynamics of fruit flies (Diptera : Tephritidae) on mango in Northern Karnataka. *Pest Management and Economic Zoology*, **11**: 103-110.

SUSHILKUMAR, PATEL, C.B. AND BHATT, R.I., 1997, Studies on seasonal cyclicity of *Bactrocera correctus* Bezzi in mango and sapota orchards using methyl eugenol trap. *Gujarat Agricultural University Research Journal*, **22**: 68-74.

THOMAS, D.B., HOLLER, T.C., HEATH, R.R., SALINAS, E.J. AND MOSES, A.L., 2001, Trap-lure combinations for surveillance of *Anastrepha* fruit flies (Diptera : Tephritidae). *Florida Entomologist*, **84**: 344-351.

UCHIDA, G.K., WALSH, W.A., ENCARNACION, C., VARGAS, R.I., STARK, J.D., BEARDSLEY, J.W. AND MCINNIS, D.O., 1996, Design and relative efficiency of Mediterranean fruit fly (Diptera:Tephritidae) bucket traps. *Journal of Economic Entomology*, **89**: 1137-1142.

VARGAS, R.I., STARK, J.D. AND NISHIDA, T., 1989, Abundance, distribution and dispersion indices of the oriental fruit fly and melon fly (Diptera: Tephritidae) in Kavai, Hawaiian Islands. *Journal of Economic Entomology*, **82**: 1609-1615.

VARGAS, R.I., STARK, J.D., PROKOPY, R.J. AND GREEN, T.A., 1991, Response of oriental fruit fly (Diptera : Tephritidae) and associated parasitoids to different colour spheres. *Journal of Economic Entomology*, **84**: 1503-1507.

VERGHESE, A., MADHURA, H.S., JAYANTHI, K.P.D. AND STONEHOUSE, J.M., 2002, Fruit flies of economic significance in India with special reference to *Bactrocera dorsalis*. *Proceedings of 6th International Fruit fly Symposium*, 6-10 May 2002, South Africa, pp.317-324.

VERGHESE, A. AND SUDHADEVI, K., 1998, Relation between trap catch of *Bactrocera dorsalis* Hendel and abiotic factors. In: *Proceedings of First National Symposium on Pest Management in Horticultural Crops*, Bangalore, pp.15-18.

VIJAYSEGARAN, S., 1985, Observations on the damage and control of melon flies (*Dacus cucurbitae* Coquillett) infesting musk melons. *Teknologi Buah-buahan*, **1**: 37-44.

VINOD KUMAR AND AGARWAL, M.L., 1998, Efficacies of different bait combinations against oriental fruit fly, *Bactrocera dorsalis* (Hendel). *Journal of Research,* Birsa Agricultural University, **10**: 83-86.

VIRAKTAMATH AND RAJITHA, 2005, Evaluation of two commercial traps against melon fruit fly *Bactrocera cucurbitae* (Coq). *Insect Environment*, **10**: 169-170.

VIRAKTAMATH, S. AND SURESH BABU, K., 2004, Species composition and population dynamics of fruit flies (Diptera : Tephritidae) on Guava. *South Indian Horticulture*, **52**(1-6): 317-323.

WAKABAYASHI, N. AND CUNNINGHAM, R.T., 1991, Four component synthetic food bait for attracting both sexes of the melon fly (Diptera : Tephritidae). *Journal of Economic Entomology*, **84**: 1672-1676.

WEISMANN, R., 1937, Die orientaierung der kirschfilege. *Rhagoletis cerasi* L. bei der Eialbege (Eine sinnephysiologiesche untersuchung). *Landwirstschftliches Jaherbuch der Schweiz*, **51**: 1080-1109.

WHITE, I. AND ELSON-HARRIS, M.M., 1992, *Fruit flies of Economic Significance : Their Identification and Bionomics*. CAB International with Australian Centers for International Agricultural Research, p.601.

STUDIES ON FRUIT FLY TRAPPING SYSTEMS BY USING METHYL EUGENOL AND PROTEIN FOOD BAITS IN GUAVA AND MANGO ORCHARDS

RAVIKUMAR P. 2006 Dr. SHASHIDHAR VIRAKTAMATH
MAJOR ADVISOR

ABSTRACT

Investigations were carried out during the year 2005-06 at Dharwad and Mummigatti to evaluate the different quantity of methyl eugenol, frequency of charging, different colours and shapes of traps as well as protein food baits and the effect of weather on trap catches of fruit flies.

Traps charged with 0.1 and 0.2 ml methyl eugenol in guava and mango respectively recorded higher trap catches. These traps could trap the fruit flies effectively upto 4 weeks and three weeks in guava and mango respectively against *Bactrocera correcta*. Whereas charging at two and four weeks intervals was effective against *B. dorsalis* and *B. zonata* respectively.

Yellow coloured traps were found to be effective in guava (71.91 fruit flies/trap/week) and black colour in mango orchards (8.68 fruit flies/trap/week). Cylinder and bottle traps were efficient in guava (33.05 and 32.75 fruit flies/trap/week) ecosystem while bottle traps were efficient against mango fruit flies (7.23 fruit flies).

Among various protein food baits, fruit fly diet, mango pulp with ammonium acetate combination attracted significantly more number of female fruit flies (10.63 and 8.88 fruit flies/trap/week).

Monitoring studies revealed the occurrence of all the three species (*B. correcta, B. dorsalis, B. zonata*) throughout the year. In guava, *B. correcta* had four peak catches in 2005-2006 while *B. dorsalis* had three during 2005 and one major peak catch during 2006 (April).

In mango, *B. correcta* had two peaks in 2005 (July and November) and one in 2006 (May) while *B. dorsalis* had totally four peaks throughout the season (July and November of 2005 and March and May of 2006). However, *B. zonata* had only one major peak in 2005 (September) and two peaks in 2006 (April and May).

In guava and mango high significant positive correlation was observed between trap catches and minimum temperature.