INTEGRATED CONTROL OF FRUIT FLY
Dacus cucurbitae Coq:
TRYPETIDAE: DIPTERA ON BITTER GOURD

BY

JALAJA. P. N.

THESIS

Submitted in partial fulfilment of the requirement
for the degree

Master of Science of Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Entomology
COLLEGE OF AGRICULTURE
Vellayani, Trivandrum

1989

DECLARATION

I hereby declare that this thesis entitled "Integrated control of fruit fly *Dacus cucurbitae* (Coquillett) Trypetidae Diptera, on bittergourd" is a bonafide record of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

JALAJA, P.N.

Vellayani,

1989.

CERTIFICATE

Certified that this thesis entitled "Integrated control of fruit fly *Dacus cucurbitae* (Coquillett), Trypetide Diptera, on bittergourd", is a record of research work done independently by Smt. Jalaja, P.N. under my guidance and supervision and that it has not previously formed the basis for award of any degree, fellowship, or associateship to her.

K.S. Remamony.
Chairman, Advisory Board.
Associate Professor
Department of Entomology
College of Agriculture
Vellayani

Vellayani,
9 - 11 - 1989.

APPROVED

Chairman:

K.S. Remamony.

Members:

1. Dr. P. Manikantan Nair.

2. Dr. George Koshy.

3. Dr. P. Saraswathy.

ACKNOWLEDGEMENTS

I wish to express my deep sense of gratitude and indebtedness to Smt. K.S. Remamony, Associate Professor of Entomology, for her sincere guidance and constant encouragement throughout the course of this study and in the preparation of the thesis.

I am extremely thankful to Dr. N. Mohan Das, Professor and Head of the Department of Entomology, for his valuable and timely help and constructive ideas during the course of the studies.

I take this opportunity to express my thanks to Smt. K. Santhakumari, Associate Professor of Entomology for the valuable help given in the course of this study.

I am grateful to the members of the Advisory Committee, Dr. P. Manikantan Nair, Professor of Plant Breeding and Dr. George Koshy, Professor of Entomology, for their co-operation and helpful suggestions during the course of this investigation and in the preparation of the thesis.

I am very much thankful to Dr. (Mrs.) P. Saraswathy, Associate Professor of Agricultural Statistics, for the kind help rendered for the analysis of the data.

I thank the staff of the Department of Entomology, for the help rendered during the period of my study.

I am also thankful to the Dean, College of Agriculture, Vellayani, for providing necessary facilities for the successful completion of the programme.

Jalaja

JALAJA, P.N.

C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

Introduction

1. INTRODUCTION

Momordica charantia L. commonly known as bittergourd is the most important summer vegetable in India (Nath, 1965). This gourd is considered to be an old world species with its native home in the Tropical Africa and Asia (Hutchins and Sando, 1941; Thompson and Kelly, 1967). The importance of the vegetable has long been accepted on account of its high nutritive value, unique medicinal properties and consumer preference. Bittergourd ranks first among the cucurbits and compare well with any other vegetable for its nutritional qualities (Gopalan *et al*., 1982). The fruit contains two alkaloids, one of them being momordicine which is reported to possess cooling, stomachic, appetising, carminative, antipyretic, anthelmintic, aphrodisiac and vermifuge properties (Blatter *et al*., 1935; Nadkarni, 1954).

The cultivation of this crop is highly remunerative particularly under irrigated conditions during summer and hence is gaining popularity among the vegetable growers of the state.

There are many pests attacking this crop. Among them the melon fly, *Dacus cucurbitae* Coq. is the most destructive one on cultivated species of cucurbits. Narayanan and Batra (1960) reported that the insect infests about twenty seven plants belonging to various families, cucurbitaceae, solanaceae and leguminaceae. Lall and Singh (1959) reported that the extent of damage to the bittergourd by the pest may go up to fifty nine per cent.

The adult lays eggs in the fruit rind and the larvae on hatching burrow and feed well protected within the fruit resulting in rotting of the entire pulp. When the fruit drops, full grown maggots pupate at a depth of 2 - 3 cm in viable soil, emerging only as adults to reinfest the crop. The absence of an exposed immature stage in the life cycle of the insect makes the curative methods ineffective for the control of the pest.

The high damage potential of D. cucurbitae invited the attention of plant protection technologist from very early days. Several control measures had been recommended against this pest. Biweekly prophylactic spraying is the common method of control now in vogue. Since the return from the crop is quite high, farmers resort to very intensive sprays during the harvesting time for producing infestation free fruit They even apply toxic and residual granules like carbofuran even during the harvesting stage of the crop. This invariably leads to residue hazards in fruits harvested from treated crop. Besides, this high cost technology is bound to become ineffecti in the long run due to the possible resistance mechanism which may develop in the insect population in due course. Hence a low cost safer technology for controlling D. cucurbitae was a long felt necessity. In this context detailed investigations in the following aspects of fruit fly control were taken up.

1. Selecting suitable attractants for trapping the adults of D. cucurbitae in the field and standardising the methods of trapping.

2. Screening types/varieties of bittergourd for locating resistant ones if any for cultivation in the field or for utilization in breeding programmes.

3. Evaluation of materials which can be used for bagging fruits to ward off the flies from egg laying.

4. Assessment of the relative efficacy of bagging, use of resistant varieties and trapping in limiting the damage caused by D. cucurbitae.

Review of Literature

2. REVIEW OF LITERATURE

Literature available on the different aspects related to the control of D. cucurbitae (Coq.) has been briefly reviewed here.

2.1. Mechanical control

Protection of individual fruits by light muslin bag was suggested by Cleghorn (1914) as a successful remedy for preventing the damage done by the melon fly *Carpomyia pardalina* (F.). He found that the bag could be removed when the fruits so protected attained the age of 6 days and the same bag could be used for protecting about 20 young fruits during each season.

Bunting and Milsum (1930) recommended the covering of cucurbits with cloth or paper bags for protection from *Dacus caudatus* (F.) and *D. ferrugineus* (F.). According to Hutson (1940) gourds covered with bags of newspaper were completely protected from infestation by *D. cucurbitae* (Coq.) but secondary rotting was more prevalent among the bagged fruits.

Miller (1940) observed that protection from infestation by *D. ferrugineus* was achieved by covering the fruits with paper, cloth or netting at the stage of development most susceptible to attack. The susceptibility varied with the type of fruits but it was generally safe to apply covers shortly after the fruits were formed.

Misaka <u>et al</u>. (1940) suggested covering the fruits with paper bags to prevent the females of <u>D. ferrugineus dorsalis</u> (Hend) from ovipositing on mango fruits.

2.2. Cultural control

Back and Pemberton (1914), Severin (1914) recommended burying the infested fruits below 3" under soil with addition of sufficient lime for destroying the larvae of the melon fly.

According to Koidsumi and Snibata (1935) the pupae in the soil could be killed by submerging the field with water. Narayanan (1953) recommended a light ploughing of the vegetable field after the crop was lifted in order to expose the pupae to the attack of parasites and predators. Wesley (1956) recommended sowing of early or late varieties of cucurbit vegetables and also raking up soil under the infested plants during winter months for destroying the hybernating pupae.

According to Narayanan and Batra (1960), turning over the soil not only destroyed the pupae but also aerated the root system. Syed <u>et al</u>. (1970) found that prohibiting the cultivation of two or more of its major food plants with different phenologies, in a single area was the most promising method to prevent the year round development of <u>D. zonatus</u> (Saunders). Pucci <u>et al</u>. (1983) reported that olive harvesting was not economically viable in years of heavy Dacus incidence unless it was carried out before the second week of November.

Alzaghal and Mustafa (1987) recommended the ploughing of the soil under olive trees in autumn and in late winter after harvesting reduced adult emergence from pupae following diapause. Collection of all fruits on or under trees at harvest also reduced the abundance of the over-wintering stages of D. oleae (Gmel).

2.3. Use of resistant varieties

Fernando and Udurawana (1941) studied the relative resistance of some strains of bittergourd to the cucurbit fruit fly. They found that one strain was consistently superior to the others in regard to both resistance to the fruit fly and yield. Nath (1966) reported the varietal resistance of gourds to the fruit fly D. cucurbitae. He observed that bottlegourd group was the most resistant and the spongegourd group the most susceptible. The degree of damage varied with the age of the fruit, the temperature, relative humidity, and time of the year. Fruit quality was reduced by even one puncture by the fly.

In pumpkin the fruit fly resistance source was located and the resistant variety Arka suryamukhi (   ) was developed (Nath et al., 1976). Khandelwal and Nath (1979) evaluated cultivars of water melon for resistance to fruit fly and found that two cultivars were resistant to the fly and the varieties from USSR, USA, Japan and other Indian cultivars were susceptible.

Darshan Singh (1976) studied field incidence of melon fly D. cucurbitae on different cultivars of bittergourd. The percentage damage of fruits ranged from 29.4 to 48.7 indicating that all the cultivars were susceptible to the attack of this fruit fly but their degree of susceptibility varied. Although no variety seemed resistant, some varieties had comparatively low infestation by fruit flies.

2.4. Physical control

Seo et al. (1974) found that when fruits of papaya heavily infested with larvae of Dacus dorsalis (Hend.) received vapour heat treatment at 44.4°C for 8.75 h no insect survived. Armstrong (1982) found that immersion for 15 minutes in hot water (50°C) disinfested the banana fruits that were infested by D. cucurbitae, D. dorsalis, Ceratitis capitata (Wied.) without detriment to either fruit quality or shelf life.

Selecting papaya fruits less than 10 quarter ripe and immersing for 20 minutes in water at 42°C followed immediately by a second immersion for 20 minutes in water at 49°C reduced infestation by D. dorsalis (Couey and Hayes, 1986).

2.5. Attractants

A plastic trap that was lighter, cheaper and easier to handle than the standard glass ones was developed by Steiner (1957). He used angelica seed oil on dental cotton as an attractant for *Ceratitis capitata*. This trap was also proved effective against *D. cucurbitae* and *D. dorsalis* when baited with appropriate lures. Lall and Singh (1960) reported that the bait containing fermented palm juice one part, saturated sugar solution one part and malathion WP 50 per cent, 5 g at the rate of 100 ml gave the maximum catch of both sexes of *D. cucurbitae*.

Cuelure was most effective in trapping *D. cucurbitae* (Alexander *et al.*, 1962). Clensel (a liquid soap containing ammonia) attracted *D. doraslis*, *D. zonatus*, *D. diversus* (Coq), *D. cucurbitae* and *D. ciliatus* (Loew) (Batra, 1964).

Ajjan (1968) compared the plastic trap developed by Steiner and modified Steiner trap with the standard glass bell shaped trap in catching adults of the olive fruit fly *D. oleae* with a 3 per cent aqueous solution of diammonium phosphate as the attractant. According to him modified trap had some advantage in saving labour, attractability and total expenses.

Monro and Richardson (1969) noted cuelure as the best attractant for Dacus tryoni (Frogg). When mixed with malathion cuelure did not change in attractiveness over more than six months, however, when mixed with DDVP it declined in attractiveness within 6 - 12 days.

ElTahir and Venkatraman (1970) reported that out of the traps baited with cuelure, trimedlure and methyl eugenol in Sudan, cuelure was found to be attractive to males of D. ciliatus but not to those of D. vertebratus (Bez.). Hydrolysed protein attractant was equal or superior to Staley No. 7, an acid hydrolysate of maize protein for attracting D. oleae (Stavrakis et al., 1970).

Doolittle et al. (1970) compared attractiveness of mixtures of cuelure and 4-(p-hydroxy phenyl) butanone for the control of melon fly. He found that the addition of 4-(p-hydroxy phenyl)-2-butanone, the probable degradation product of cuelure, to cuelure in increasing amounts did not diminish its attractiveness to D. cucurbitae.

Trap baited with methyl eugenol to attract the males gave effective control of D. dorsalis in a mango orchard. The methyl eugenol was used at 1% with 0.1% carbaryl and the trap was replenished monthly (Lakshmanan et al., 1973).

Males of D. cacuminatus (Her) were attracted to oil extracted from the leaves of the native plant Ziera smithi ( ). It was found that methyl eugenol was the main constituent (Fletcher et al., 1975). A tangle foot coated McPhail trap painted day light fluroscent yellow captured more olive flies D. oleae than a tangle foot coated clear one, when both were baited with 2% ammonium sulphate and water (Prokopy and Economopoulos, 1975).

A tub shaped plastic trap baited with a mixture of protein insecticide bait and borax containing dichlorvos impregnated plastic trap was as least as effective as the McPhail invaginated glass trap baited with the same mixture in capturing adults of D. dorsalis and D. cucurbitae (Nakagawa et al., 1975).

Shah and Patel (1976) observed that 40% of the essential oil content of Ocimum sanctum (Linn) consisting of methyl eugenol was a sex attractant for the males of Dacus correctus (Bezzi). Jacobson et al. (1976) identified acetic acid and acetic anhydride, the contaminants in commercial cuelure, as responsible for its transient attraction of adult females of Ceratitis capitata and D. cucurbitae.

Economopoulos (1977) in his studies on the control of D. oleae by fluroscent yellow traps indicated that males may be more attracted to the yellow traps than females.

Hooper and Drew (1978) compared the efficiency of two traps and found that Steiner traps caught significantly more male tephritids than the Bateman trap. Hooper (1978) observed that captures of male tephritids responding to methyl eugenol and cuelure were significant when both attractants were combined in a single trap.

Effects of malathion and carbaryl with or without the attractant gur on the incidence of D. cucurbitae on long melon were studied and found that carbaryl was superior to malathion in reducing infestation (Kavadia et al., 1978).

Ricci and Ceccarelli (1979) observed the captures of D. oleae by means of coloured Prokobol trap and found that many factors contributed to the significant difference between the number and sex of adults caught in the traps, notably the olive varieties, the trap surface (interior and exterior), the date of capture and the interaction between them.

Attraction of D. oleae to four traps like McPhail glass trap baited with 2% Zital-98 odour lure and 1.5% borax water solution (Z), fluroscent yellow panels (FY), yellow panel (Y) and yellow pherion traps (YP) were observed. All traps were covered with sticky material. The Z traps were found to attract much larger number of D. oleae than the colour traps (Economopoulos, 1979).

Males of *D. dorsalis* (more than 20 days old) were strongly attracted to methyl eugenol when compared to *D. cucurbitae*, their attraction to methyl eugenol was found to be significantly different. The percentage of *D. dorsalis*, *D. umbrosus* (F) and *D. cucurbitae* caught was 43.3, 47.5 and 4.2 per cent respectively (Ibrahim and Hashim, 1980). Vita *et al*. (1980) contented, after laboratory tests and subsequent field tests, that ammonium polyacrylate, ammonium salts of the alternating ethylene maleic acid co-polymer, micro encapsulated ammonium acetate and micro encapsulated ammonium carbonate were all attractive to the olive pest, *D. oleae*.

Catches of *D. oleae* with bottle traps containing diammonium phosphate hung on parts of the trees facing west caught fewer adults than did any other traps (Longo and Benfatto, 1981). Certain solutions of ammonium bicarbonate were highly effective attractant against *D. tryoni* (Bateman and Morton, 1981).

Zervas (1982) suggested a new trap with attractant ammonium sulphate which remained effective for six months and evaporating rate was low (6 - 10 ml/day) even in hot months. Katsoyannos (1983) compared Rebell yellow sticky traps with McPhail traps both baited with 2% ammonium sulphate and found that McPhail traps caught 4.2 - 46.3 and 2.4 - 16.7

times as many adults of *D. oleae* and *Ceratitis capitata* respectively as the Rebell traps.

Economopoulos and Papadopoulos (1983) tested various kinds of sticky traps with different baits for their attractiveness to *D. oleae* and found that McPhail traps with Entomozyl (of unstated composition, each used at 2% in a 1.5% aqueous solution of borax) caught significantly higher number of adults than the Rebell traps.

Plexiglas panels coated with temocid adhesive (Chromotropic traps) hung at medium and low levels of the trees caught more adults of *D. oleae* than traps at the higher levels. Bagnoli *et al.* (1983), Ricci *et al.* (1983) investigated the levels of infestation by *D. oleae* in relation to the presence of the Chromotropic traps in olive varieties and found that use of one trap/tree was enough for monitoring adult population and for forecasting future levels of infestation.

Steam distillation extracts of the flower buds and leaves of the labiate *Ocimum sanctum* caught significantly more males of *D. dorsalis* than traps baited with 1 - 15% methyl eugenol (Tan, 1983). Z-8 methyl 6 Nonenyl acetate was most attractive substance for adults of *D. cucurbitae* (Voaden *et al.*, 1984).

Yellow sticky rectangle with ammonium acetate slow release dispenser is an efficient long lasting trap for Dacus oleae (Economopoulos and Stairopoulos-Delivoria, 1984). A new cylindrical attractant trap baited with 0.5 ml methyl eugenol with 50 μl permethrin caught more D. dorsalis and D. umbrosus than those baited with methyl eugenol alone (Tan, 1984).

Broumas (1985) concluded that using yellow traps which were coated with adhesive or treated with deltamethrin and baited with both ammonium carbonate and the sex pheromone of the tephritid as a practical method with good potential for the protection of olives against D. oleae.

Wen (1985) evaluated four attractants for their efficiency in bait traps against D. cucurbitae and found that cuelure and isolan were more effective and more persistent than methyl eugenol and protein hydrolysate.

Addition of synthetic attractant cuelure to methyl eugenol reduced the capture of females of D. tryoni, D. neohumeralis (Hardy), D. cacuminatus in coloured sticky traps and protein baited traps (Hill, 1986).

2.6. Repellents

Olive juice applied on fresh foliage repelled D. oleae, but the repellent effect decreased as the deposit dried

(Vita *et al.*, 1977). Alcoholic extract of neem seed oil (5%) completely deterred oviposition by *D. cucurbitae* on bitter-gourd (Singh and Srivastava, 1985).

2.7. Use of hormones

Musaline (synthetic sex pheromone) and 2-9-tricosene, at all doses were markedly attractive to females of *D. oleae*. Z-9-monodecene at 150 µl attracted males much more than females (Niccoli, 1975). Fytizas and Mourikis (1977) reported the susceptibility of *D. oleae* to the juvenoid, methoprene altosid. He found that the treatment of larvae inhibited development to the extent of 28.9-43.7% depending on age. Administration of the hormone in the diet caused death probably through an antifeedant effect.

Methoprene and possibly other synthetic juvenile hormone analogue might be used as a means of control against *D. oleae* (Orphanidis, 1978). Cover sprays containing methoprene applied in olive groves reduced the survival of pupae to the extent of 89.7% (Orphanidis and Kapetanikis, 1979).

Haniotakis (1981a) recommended a pheromone trap, at the density of five trap/tree, in the experimental field and one trap/tree in the periphery for mass trapping *D. oleae*. Combination of pheromone traps with odour or colour traps was more attractive than any one trap alone (Haniotakis, 1981b).

Mazomenos *et al.* (1983) tested the effects of pheromone dispenser and synthetic pheromone (1,7 dioxaspiro 5.5) undecane on capture of males of *D. oleae*. On the basis of the number of males caught and the length of active period polyethylene vials were the most effective of the dispenser tested and that 25 - 200 mg attracted males of *D. oleae* for four months. Higher concentration may have an inhibitory effect.

Thakur and Asok Kumar (1984) reported that diflubenzuron and penfluron induced complete sterility in either sexes of *D. dorsalis* when applied topically to newly emerged flies at a dose of 5 µg/fly.

Mazomenos and Haniotakis (1985) suggested that out of the four synthetic sex pheromone components tested for the attraction of males of *D. oleae*, component I (1,7, dioxaspirol 5.5) undecane was more attractive than any of remaining three components alone. They found that a combination of all four are more attractive than component I alone.

Plywood rectangles dipped in 0.1% ai aqueous solution of deltamethrin for 15 minutes baited with two dispenser, one containing a mixture of sex pheromone and the other ammonium bicarbonate (a food attractant for both sexes) were used for the control of *D. oleae* (Haniotakis *et al.*, 1986).

Stephen *et al*. (1987) reported that life cycle of the oriental fly *D. dorsalis* in papaya was completely interrupted by a coating of a standard commercial fruit wax containing the insect growth regulator methoprene.

Thakur and Asok Kumar (1988) studied the sterilant effects of ethyl methane sulphonate on *D. dorsalis*. They found that aqueous as well as acetone solution of ethyl methane sulphonate (EMS) induced significant sterility in both sexes of fruit fly but in comparison aqueous EMS was more effective than acetone EMS.

2.8. Irradiation and eradication

Dose of five krad sterilized both sexes of *D. tryoni*. Doubling this dose prevented egg laying by treated female and permitted only six eggs per million to hatch and none to survive when irradiated males were mated as a quarantine treatment. This could provide adequate safe guard against the spread of this pest species (Shipp and Osborn, 1968).

Eradication through annihilation of the male population of *D. dorsalis* in Mariani Islands by the distribution of fibre board squares impregnated with methyl eugenol and naled every two weeks for 4½ months was reported by Steiner *et al*. (1970).

Field trials with fibre board blocks soaked in a mixture of 95% cuelure and 5% naled at the rate of about 0.9 oz/block gave 99% control of male population of D. cucurbitae (Cunningham and Steiner, 1972). Application of thickened foliar sprays of methyl eugenol and a toxicant (either 5% technical naled or 25% technical malathion) at 5 - 10 $lb/mile^2$ reduced the number of males taken in traps by over 98% (Cunningham et al., 1972).

Use of male annihilation technique reduced the infestation by D. dorsalis from a maximum range of 23 and 14.3% to final level of 3 to 0.5 per cent (Balasubramanium et al., 1972).

Tzanatakis (1972) reported the current status and prospects of applying the sterile release method against D. oleae. He found that for good results the pupae should be irradiated as late as possible in the pupal stage, field release should begin well ahead of the fruiting season and should be made at short intervals and that the release points should not be more than 200 m apart.

An eradication campaign comprising of 15 weekly applications of a bait spray containing a protein hydrolysate and malathion, annihilation of males by means of pieces of thick string impregnated with cuelure mixed with malathion and distributed on all standing vegetations indicated that use of cuelure traps rapidly reduced the number of D. tryoni in the island (Bateman et al., 1973).

Male irradiated at a dose of 16 krad within 24 hours after emergence gave 98% sterility but the dose of irradiation required for effect when male pupae were treated three days before adult emergence was seven krad. They found that the best proportion of sterile flies in a population for sexual competition was found to be eight sterile males to one normal male (Cavallore et al., 1973).

Irradiation at a dose of 25 krad prevented the adult emergence of D. dorsalis and D. cucurbitae (Thomas and Rahalkar, 1975). Hopper (1975) observed that a dose of eleven krad caused complete sterility in males of D. cucumis (French). When females were given six krad they became totally sterile.

Application of sprays of a mixture of 80% cuelure, 5% naled and 15% Thixcine (a thickener) from an air craft at the rate of 0.8, 2, 3.4 and 8.5 lb mixture/square mile reduced population of adult males of D. cucurbitae by 92, 97, 93 and 95% respectively for 11 - 15 days (Cunningham et al., 1975).

Release of sterile flies in Kume Islands reduced the hatchability of eggs of D. cucurbitae from 91% to 29% (Iwashashi et al., 1976). Iwashashi (1977) reported that eradication of D. cucurbitae from the island had been achieved after the release of 264 x 10^6 treated pupae. Harmful effects of irradiation of D. cucurbitae as mating competitiveness was negligible with a dose of seven krad which was used in the eradication project (Teruya and Zukeyama, 1979).

Sonda and Ichinohe (1984) eradicated D. dorsalis using male annihilation method with methyl eugenol as an attractant. Koyama et al. (1984) got successful eradication of D. dorsalis with sufficient dose of lure-toxicant until the number of males caught in monitor traps was reduced to about 0.01%.

Eta (1986) reported a successful eradication programme using protein hydrolysate bait sprays with malathion together with traps containing cuelure to eliminate males.

2.9. Biological control

Fullaway (1915) successfully introduced and established Opius fletcheri (Silv) in Hawaii for control of melon fly D. cucurbitae. An unidentified species of Opius from North Borneo proved as an effective parasite of D. cucurbitae in the laboratory and was released in large numbers in the field.

Batra (1954) recommended biological control of D. cucurbitae by release of parasite of O. fletcheri in the infested cucurbit fields in India. Clausen (1956) reported the parasitism of Opius fletcheri on D. cucurbitae being low in summer.

Nishida and Bess (1957) reported that the parasite O. fletcheri was successful only in the wild areas whereas the fruit fly D. cucurbitae was found to breed on the fruits Momoridca balsamina (Linn.). D. cucurbitae was found parasitised by O. fletcheri, Syntomosphyrum indicum (Silv.), Spalansis sp. and Ipobracon sp. but Opius fletcheri was found more effective and widespread than other parasites in northern India (Nishida, 1963).

2.10. Chemical control

2.10.1. Cover sprays

Melis (1957a) suggested that low volume sprays of diazinon and malathion gave good results in the control programme of D. oleae in Italy. Melis (1957b) applied o,o, dimethyl S-methyl phosphorodithioate at 0.06 per cent for the control of D. oleae. All treatments gave complete kill of the larvae within the olives.

Orphanidis et al. (1958) showed the effectiveness of dimethoate (Rogor) spray at 0.03 to 0.06 per cent for the control of D. oleae.

Nicotine sulphate 0.1 per cent, endrin 0.02 per cent and parathion 0.025 per cent reduced the bittergourd fruit fly incidence effectively and the latter two gave higher yield. They recommended application of DDT 0.1 per cent three times with a fourth round of endrin 0.02 per cent or parathion 0.025 per cent (Sreenivasan and Narayanaswamy, 1960). Malathion 25% WP when used at dilutions of 1 : 800 for young leaves and 1 : 400 for old leaves gave excellent results for the control of *D. cucurbitae* (Chen, 1960). The most effective materials for the control of *D. oleae* were dimethoate, bopord oil and parathion with copper sulphate (Russo, 1960).

Carbaryl was less toxic than fenthion, trichlorphon and parathion. Fenthion was more persistent than trichlorphon and parathion against *D. ciliatus* (Saddik *et al.*, 1964). Azab *et al.* (1964) studied the relative toxicity of some common insecticides to the adults of pumpkin fly *D. ciliatus*. He concluded that malathion 0.23 per cent toxicant remained effective for five days, after which the percentage mortality had decreased from 98 to 12. Trichlorphon at 0.2 per cent remained toxic for only three days after which the percentage mortality had decreased from 84 to 7.

Sprinkling or a coarse spray with a liquid bait containing one per cent yeast protein and 0.1 per cent malathion is an effective method to control the melon fly D. cucurbitae without risk of poison hazards or phytotoxicity (Dale and Nair, 1966). Planes and Del Rivero (1966) recommended three application of fenthion, diazinon or dimethoate at intervals of about a month which provided complete protection against D. oleae.

Sprays of dimethoate, ethoate methyl, dicrotophos mecarbam and formothion at the rate of 0.04 and 0.06 per cent applied three times each year caused total mortality of the immature stages and marked reduction in adult population of D. oleae (Damiano, 1967). Best results were obtained with meanzon (pp 175) applied at 0.1 per cent for control of D. oleae (Fenili and Zocchi, 1967).

Various combinations of Bordeaux mixture, copper sulphate, parathion, dimethoate, Bopard oil, ethoate-methyl and carbaryl were tested in mixed sprays and dust formulations for control of D. oleae and found that spray gave better control than dust containing same compound or normal volume sprays were more effective than low volume ones (Russo, 1968). Cover sprays of carbaryl and trichlorphon 0.1 per cent and carbaryl 0.05 per cent applied four times beginning from flowering time supplemented by application of aldrin or heptachlor to the soil against larvae and by prompt destruction of infested fruits gave effective control against melon fly *D. cucurbitae* (Das *et al.*, 1968).

Orphanidis *et al.* (1969) compared carbamate insecticides with OP insecticides in hydrolysed protein baits for control of olive fly *D. oleae* and found that bait sprays containing five per cent Staley No.7 hydrolysed protein bait in Dimetilan 1 per cent was superior to all other carbamates and all the organophosphate compounds tested.

Two formulations of dimethoate, formothion and endothion gave good residual control of eggs and larvae of olive fruit fly *D. oleae* and showed the evidence of phytotoxicity (Awadallah and Nadim, 1970). Saddik and Rizkallah (1970) compared sprays of 0.1 per cent fenthion, 0.1 per cent parathion or 0.24 per cent trichlorphon for the control of *D. ciliatus* on cucumber, increased the percentage of uninfested fruits from 87.6 for no treatment to 97.2, 94, 95.6 respectively and the yield/plot from 5.4 kg for no treatment to 11.6, 8.3 and 8.9 kg respectively.

Merinphos, dimethoate, diazinon and methomyl gave high mortality of adults of *D. caudatus* (Chang and Peng, 1971). High volume or low volume sprays of Itilon (12.5% dimetilan and 25% diazinon) afforded good control of *D. oleae* (Bugiani *et al.*, 1971). Out of the eight insecticides tested for the control of melon fly D. cucurbitae infesting snake-gourd 0.1 per cent dimethoate or fenthion gave good results (Nagappan et al., 1971).

Dimethoate and naled were the most toxic to D. dorsalis, D. cucurbitae and Ceratitis capitata (Keiser et al., 1973).

Good control of melon fly D. frontalis (Becker) was obtained by using three applicntion of either 2 per cent diazinon or 0.2 per cent fenthion beginning at the time of fruit set (Ba-Angood, 1977).

Out of seven insecticides tested against D. cucurbitae fenthion was consistently most toxic followed by malathion, tetrachlorvinphos, trichlorphon and endosulfan. Carbaryl and DDT were almost ineffective (Bhatt and Bhalla, 1978).

Orphanidis and Kalmoukos (1979) concluded that adults of olive fruit fly D. oleae were strongly attracted by baits of protein hydrolysate containing dimetilan with mixtures of organo phosphorus as a good bait spray method for control of D. oleae.

Adults of D. dorsalis were paralised by sublethal doses of permethrin or cypermethrin at 15°C but most of them recoved after transfer to 30°C (Tan, 1982). Fenthion was the most effective compound against D. cucurbitae (Shivarkar and

Dumbre, 1985). Synthetic pyrethroids, permethrin, fenvalerate and cypermethrin each at 100 g ai/ha and deltamethrin at 15 g ai/ha gave significantly better control of infestation by the melon fly *D. cucurbitae* (Ravindranath and Sasidharn, 1986). In small plots malathion-protein hydrolysate bait sprays applied to border on the treller posts supporting the vines of passion fruit were almost as effective as cover sprays with 0.4 per cent fenthion in preventing damage of *D. tryoni* (Hargreaves *et al*., 1986).

Four spray applications of 0.2 per cent carbaryl at 3, 5, 9 and 11 weeks after sowing proved most effective against the fruit fly *D. cucurbitae* (Pareek and Kavadia, 1988).

2.10.2. Fumigants

Fumigation with methyl bromide 32 g/m^3 for 2.5 h at 21.1°C and post fumigation storage for six days at 7.2°C is suitable integrated treatment to control the infestation of fruit flies *D. dorsalis* and *D. cucurbitae* (Seo *et al*., 1971). Ethylene dibromide 8 g/m^3 at 30-32°C was most effective against D. dorsalis infesting mango fruits (Shimada *et al*., 1972).

Heating the mango fruits in water at 46.3°C for 20 minutes and fumigating them with ethylene dibromide at 8 or 12 g/m^3 in wooden field boxes at 21.1°C for 2 h and refrigerating them at 7.6°C for four days resulted in the complete control of D. dorsalis and Ceratitis capitata (Seo et al., 1972). Fumigating ethylene dibromide at a rate of 24 g/m^3 at 20°C gave excellent control of D. tryoni (Rigney and Wild, 1975).

Fumigation for 2 h at 20°C with 1,2 dibromoethane at 20 g/m^3 was found to be an effective treatment for D. tryoni in mangoes (Swaine et al., 1975). Ethylene dibromide 20 g/m^3 was sufficient for fumigation against D. dorsalis (Anand and Ramachandani, 1984).

Armstrong and Garcia (1985) reported that methyl bromide 32 g/m^3 for 4 h and 48 g/m^3 for 2 h at 19°C or above and normal atmospheric pressure were intended to replace the ethylene dibromide quarantine fumigation schedule for D. cucurbitae and D. dorsalis.

2.10.3. Soil insecticides

Aldrin and heptachlor were highly effective against larvae of D. cucurbitae and were much superior to DDT, BHC and carbaryl when applied at 4 lb per acre. Aldrin and heptachlor remained effective up to 16 days permitting less than 50 per cent survival of the larvae (Dale et al., 1966).

Gupta and Verma (1978) found that Aldrin 10 per cent was the most effective among the nine insecticides tested against the larvae of D. cucurbitae.

2.11. Integrated control

Spray of foliofume and soap afforded economic protection to the fruits of ampalaya attacked by D. cucurbitae. Picking and burning of infested fruits was an useful auxillary measure (Altamirano and Macabasco, 1960). Lall and Singh (1969) studied that biology and control of melon fly D. cucurbitae and found that the short green variety of the bittergourd showed high resistance to the flies. The sweetened-spray of endrin 0.02% provided 60% protection. The bait consisting of toddy, mango leather, fermented palm juice, citronella oil and diazinon gave the maximum catches of both male and female flies. Use of sterile insect technique and poisoned methyl eugenol traps in citrus orchard resulted in the reduction of fruit losses from 6.7 to 0.018 per cent in C. poinensis (   ) and from 5.2 to 0.13 per cent in the C. tantan (   ) (Lee and Chang, 1978).

Sterile insect technique could be combined with the use of parasites to control the immature stages of D. oleae. Parasites could also be used concurrently with coloured traps (Economopoulos, 1978).

Yellow sticky traps with pheromone attractant and ammonium hydroxide were used in pest management trial against _D. oleae_. As a result of this and careful monitoring of the population, only one insecticidal spray application was necessary as compared with three in treatments without trapping (Broumas _et al_., 1983).

An integrated control of _D. frontalis_ revealed that insecticides should be applied only in the late afternoon and to field edges. Groups of rest plants might be used as trap plants and should be treated with bait sprays (Steffen, 1983). Control measures against _D. tryoni_ include cultural control such as regular collection and destruction of all fallen and infested fruits and chemical control using poison baits, sprays of malathion and protein hydrolysate, or cover sprays of dimethoate and fenthion. The braconid _Opius oophilis_ (F.) is an egg parasite of _D. tryoni_ but is only reported to have a small effect on the fruit fly population. Methods of eradication include the poison bait sprays, male attractants and the release of sterile male flies (Maddison, 1983).

Materials and Methods

3. MATERIALS AND METHODS

3.1. Rearing of *Dacus cucurbitae*

Bittergourd fruits infested with *D. cucurbitae* were collected from the college farm. The infested fruits were kept vertically in a cylindrical jar (25cm x 15cm) with 8 cm layer of moist sand below. In 3 - 4 days the full fed maggots wriggled out of the fruits and entered the sand for pupation. When all the maggots dropped down, the rotten pulp of the fruits were removed. The jar was kept undisturbed for two days and then the sand was carefully transferred to a tray and the pupae were collected. Forty apparently healthy pupae each were collected and kept in petri dishes and glass chimneys placed over the same, the top of which was closed with a piece of muslin cloth and kept in position with a rubber band. The flies emerging from the pupae remained in the chimney and they were collected and used for different experiments. The flies emerging on each day were kept separately so that the flies of known age could be obtained for the different experiments.

Continuous breeding was done in the laboratory to ensure the availability of flies in adequate numbers throughout the study. The adult flies (males and females) were released in a glass jar (6" x 4") provided with a cotton swab soaked in honey diluted with water (1 : 100). Tender snakegourd fruits were placed at the base of the jar for egg laying. The flies laid eggs by puncturing the surface tissues and these fruits were transferred at the end of every 24 h to jars (9" x 6") containing sand at the bottom. The rearing was continued following the procedure described above.

3.2. Laboratory screening of materials for attracting the adults of *D. cucurbitae*

A wide range of easily available materials were screened for their potency to attract the fruit flies on bittergourd.

3.2.1. Conditioning of test insects

One day old healthy active adults of *D. cucurbitae* were collected from laboratory culture (vide. para 3.1) using 10cm x 3cm glass tubes and were transferred to cylindrical glass jars. They were kept without any food material for 12 h prior to the commencement of the experiments.

3.2.2. Exposing the test materials to the insects

Insect proof wooden cages (1m x 1m x 1m) having the sides and top closed with plastic wire net (mesh 1 mm^2) was used for the purpose.

Cotton swab (2 g) soaked in 10 ml of the bait material, diluted to the required concentration, was placed at the centre of a watch glass of 6 cm diameter. The watch glass with the bait was placed at the centre of the bottom of the cage. Fifteen numbers each of preconditioned flies collected in a clean specimen tube were released into each cage.

3.2.3. Fixing the range of doses of the test materials to be tried as attractant

Twelve materials were screened for their effectiveness as attractants to the adults of *D. cucurbitae* in an observational trial. The materials were eugenol, eucalyptus oil, citronella oil (supplied by M/s. Dev and Company, Cochin), borax, ammonium phosphate (Scientific Supplies, Trivandrum), vanilla essence, jaggery, sugar, vinegar, honey, toddy and bittergourd fruits (procured locally).

The preliminary trial was conducted using widely spaced concentrations of each material so as to fix a probable range at which each material attracted the flies. Those materials which failed to elicit positive response from the flies were excluded in further experiment. Based on the screening six materials which showed attractiveness of the flies were chosen for further experiments.

3.2.4. Fixing optimum dosage of the selected attractants

Graded concentrations of the materials within the observed effective range were prepared by diluting the stock material with distilled water.

The number of flies attracted to the bait was recorded at intervals of 10 minutes up to a period of 90 minutes. Then the observations were made at 6, 12, 24, 48 and 72 h after exposure. The data were subjected to statistical analysis.

3.3. Field evaluation of materials selected as attractants for *D. cucurbitae*

The field experiment was conducted at the Agricultural College Farm, Vellayani. The land was prepared by digging, breaking clods, levelling and removing weeds. Plots of 4 x 4 m were taken with bunds 50 cm wide around each plot. Four pits of 60 cm diameter were taken in each plot. FYM @ 10 kg was applied in each pit and thoroughly mixed with soil. Urea, super phosphate and muriate of potash were added to give 4 g, 55 g and 20 g of NPK/pit respectively. Four to five seeds were sown in each pit. Watering was done once daily till flowering and twice daily after flowering. After germination three healthy seedlings alone were retained in each pit. Weeding and earthing up were done 30, 45 and 60 days after sowing. Top dressing with urea 4 g per pit was done at the time of each earthing up.

To ensure a uniform population of fruit flies in the experimental fields, adult flies reared out in the laboratory were released @ 20 flies/plot. The release was repeated at biweekly intervals commencing from the time of flowering.

3.3.1. Baiting the adults of *D. cucurbitae* in field with selected attractants

The attractants included in the experiment were sugar, jaggery, honey, toddy (fermented), vinegar and ripe bittergourd fruits. These showed significant attraction of the flies in the screening trial.

Solution of each material was prepared using distilled water. Ten ml of each solution was dripped on to cotton swab (2 g) and 15 mg ai of carbofuran was sprinkled on it. In the case of bittergourd, ripe fruit was cut lengthwise in 5 cm long bits and carbofuran (15 mg) was sprinkled over the cut surface. The attractants were placed in traps made of clean empty coconut shells hung with GI wires. One trap was placed at the centre of each plot.

The experiment was laid out adopting a randomised block design and each treatment was replicated thrice. The adults of *D. cucurbitae* found in each trap, dead or moribund, were counted and recorded at intervals of 24 hours for four days from the time of exposure. Those flies which did not show any movement were considered dead and those which showed slight movement as moribund. The data were subjected to statistical analysis.

3.3.2. Evaluation of different varieties of banana and honey as attractant to *D. cucurbitae* in the field

The experiment was conducted using four different varieties of banana taking honey as standard (best treatment selected from the experiment described in para 3.3.1). Banana varieties included in the experiment were nendran, poovan, palayankodan and rasakadali.

The fruits of each of the four varieties were cut lengthwise and crosswise to study the effect of the surface area of the cut portion on the attraction of the flies. Carbofuran (15 mg ai/trap) was spread over the pulp at the cut surface. The bait was kept in traps as described in para 3.3.1.

The experiment was laid out in a randomised block design with three replications for each treatment. The total number of adult flies found dead or morbid in the traps were recorded at 24 hour intervals for four days from the time of exposure. The data were subjected to statistical analysis.

3.4. Assessment of the relative susceptibility of forty seven bittergourd accessions to *D. cucurbitae*

Forty seven accessions raised by National Bureau of Plant Genetic Resources (NBPGR) at Vellanikkara were screened for their relative susceptibility to fruit flies (vide Table 4).

The total number of fruits and the number of infested fruits in each plot were recorded at weekly intervals commencing from first harvest. The mean percentage of the number of infested fruits in each variety was calculated. The data were subjected to statistical analysis. The varieties/accessions were grouped into five categories following the method of Nath (1966), modified with reference to the extent of infestation observed in the present series of experiments. The groups identified were highly resistant (HR) (1 - 5% infestation), resistant (R) (5.1 - 12%), moderately resistant (MR) (12.1 - 25%), susceptible (S) (25.1 - 38%) and highly susceptible (HS) (above 38%).

3.5. Assessment of the relative susceptibility of selected varieties/accessions of bittergourd to *D. cucurbitae*

Seven accessions selected from the experiment described in para 3.4 (two resistant accessions and five moderately resistant ones), four additional accessions obtained from the collections of NBPGR, two cultivars collected from Vellayani viz. local greenish white (LGW) and local green (LG) and Priya (an improved susceptible variety as check) were included in the experiment.

The experiment was laid out in field at the College of Agriculture, Vellayani, following the methods described in para 3.3 and adequate population of flies was ensured by periodical release. Randomised block design was adopted for the lay out with fourteen treatments (vide Table 5) in the experiment, each replicated thrice.

The total number of fruits, number of infested fruits, total weight of fruits, total weight of infested fruits, in each plot were recorded at the time of each harvest. The mean percentage of the number of infested fruits and percentage weight of infested fruits were calculated and data were subjected to statistical analysis. The varieties/ accessions were grouped into different categories as described in para 3.4.

The intensity of the fruit damage in the different varieties and the effect of different varieties on the development of _D. cucurbitae_ were assessed by observing the maggots, pupae and adults emerging from 250 g samples of infested fruits collected from each treatment and maintained in the laboratory. The infested fruits were kept in the laboratory in glass troughs each containing a thin layer of sand at the bottom. When the maggots attained full growth, the decayed fruit parts were removed and the number of maggots were counted. They were allowed to pupate and the number of pupae were counted. Number of adult females and males emerging from each lot was also recorded. The experiment was repeated thrice and each experiment was treated as one replication in analysing the data statistically.

3.6. Assessment of the effect of bagging the fruits with different materials in protecting them from fruit fly incidence

Bittergourd crop was raised in field following the methods described in para 3.3. Variety priya was used. Adequate population of flies was ensured by periodical release (vide para 3.3). The treatment included (i) cloth bag (30cm x 15cm) stitched with fine muslin cloth, (ii) paper bag (30cm x 15cm) made out of ordinary news paper with sides pasted, (iii) polythene bags (30cm x 15cm) sides heat sealed and (iv) control without any protection.

Twenty plants were selected randomly from the field for each of the above treatments. A sample of thirty fruits each, just set, were covered randomly with each of the different types of bag (cloth bag, paper bag and polythene bag). A set of 30 fruits kept tagged and uncovered was observed as control. The bags were kept intact till harvest.

The percentage of fruits damaged by D. cucurbitae and the size and weight of fruits obtained in different treatments were assessed at harvest.

3.6.1. Effect of varying periods of protection of bittergourd fruits after setting on the extent of damage caused by D. cucurbitae

Ninety fruits randomly selected were covered with polythene bags just at the time of fruit set. The bags were removed from 15 fruits each on 2, 4, 6, 8, 10 and 12th day after bagging. The fruits thus exposed at different periods after setting were tagged and observed. The number of infested fruits were recorded. Percentage of infestation was calculated and the data were subjected to statistical analysis.

3.7. Evaluation of different methods of control against D. cucurbitae

The methods found effective in the different experiments for limiting the damage caused by fruit flies were evaluated in a field experiment taking the different methods as treatments.

The crop was raised as described in para 3.3. Adequate population of the flies were maintained in the field by making periodical release (vide para 3.3). The treatments included in the experiment were -

(i) Trapping of flies

Collection of adult flies with bait traps: Ripe palayankodan fruits cut crosswise and sprinkled with carbofuran granules were kept in coconut shell and hung among the bittergourd plants @ one trap per 4 m^2 area. The bait material was changed once in every week and the same was kept in the field throughout the fruiting season starting from the time of initial flowering.

(ii) Mechanical protection alone

This was provided to the fruits just from the time of fruit set using polythene bags. The bags were removed on the 8th day after the setting of each fruit.

(iii) Trapping and mechanical protection

Combination of treatments (i) and (ii).

(iv) Chemical control

Malathion (0.05%) sprayed at weekly intervals from the commencement of flowering

(v) Control

The plots sprayed with water alone.

The effect of the treatments was assessed by recording total weight of fruits, number of infested fruits and weight of infested fruits at the time of each harvest. The mean percentages of fruits (number and weight basis) were calculated from the data and the data were subjected to statistical analysis.

The number of adult flies caught in the traps were also recorded daily. These data also were analysed statistically.

Results

4. RESULTS

4.1. Laboratory evaluation of different materials as attractants for baiting the adults of *D. cucurbitae*

The results relating to the experiment and the results of the statistical analysis of the data are presented in Table 1. Among twelve materials screened in the experiment eugenol, citronella oil, eucalyptus oil, borax, ammonium phosphate and vanilla essence did not show any attraction Vinegar which showed slight initial attraction failed to attract any fly from the sixth hour after exposure. Among the remaining six treatments, as seen from the means of fourteen observations spread over a period of 72 hours after exposure, ripe bittergourd fruit was the best attractant for trapping the flies of *D. cucurbitae*, the mean number of flies attracted per observation being 8.78. The attraction of honey, jaggery and sugar showed a positive association with the dosage. At the highest dose of 1% honey attracted the maximum number of flies (7.05 per observation) and it was closely followed by jaggery (6.67) and sugar (6.01) the differences among the three being statistically insignificant. At the middle concentrations also the number of flies, attracted by honey, jaggery and sugar were on par the mean

Table 1. Laboratory evaluation of attractants for baiting the adults of <u>Dacus cucurbitae</u>

attractants used and concentration	mean number of flies attracted at different intervals after exposure														mean
	minutes									hours					
	10	20	30	40	50	60	70	80	90	6	12	24	48	72	
sugar 1%	4.32 (2.31)	4.97 (2.44)	5.32 (2.51)	7.31 (2.88)	6.64 (2.76)	8.64 (3.11)	11.26 (3.50)	11.95 (3.60)	12.30 (3.65)	0.00 (1.00)	3.65 (2.16)	6.28 (2.70)	4.66 (2.38)	3.32 (2.08)	6.01 (2.65)
sugar 0.5%	3.58 (2.14)	4.97 (2.44)	5.90 (2.63)	4.63 (2.37)	5.56 (2.56)	6.28 (2.70)	6.50 (2.74)	8.51 (3.08)	8.89 (3.14)	0.00 (1.00)	0.91 (1.38)	4.97 (2.44)	5.32 (2.51)	1.64 (1.63)	4.48 (2.34)
sugar 0.25%	2.32 (1.82)	3.65 (2.16)	5.30 (2.51)	5.50 (2.55)	4.97 (2.44)	6.64 (2.76)	6.64 (2.76)	7.92 (2.99)	7.92 (2.99)	0.00 (1.00)	0.00 (1.00)	1.94 (1.72)	3.28 (2.07)	0.00 (1.00)	3.52 (2.13)
honey 1%	7.92 (2.99)	7.31 (2.88)	8.33 (3.05)	9.31 (3.21)	10.33 (3.37)	10.33 (3.37)	9.90 (3.30)	11.65 (3.56)	11.99 (3.60)	0.55 (1.24)	6.66 (2.58)	6.66 (2.77)	3.32 (2.08)	2.00 (1.73)	7.05 (2.84)
honey 0.5%	5.30 (2.51)	4.63 (2.37)	5.90 (2.63)	6.58 (2.75)	6.64 (2.76)	7.92 (2.99)	8.66 (3.11)	9.94 (3.31)	10.30 (3.36)	0.30 (1.14)	3.65 (2.16)	3.97 (2.23)	2.32 (1.82)	1.00 (1.41)	5.90 (2.47)
honey 0.25%	4.97 (2.44)	4.97 (2.44)	6.28 (2.70)	5.56 (2.56)	6.98 (2.82)	8.33 (3.05)	8.64 (3.11)	8.98 (3.16)	8.98 (3.16)	0.00 (1.00)	3.32 (2.08)	3.58 (2.14)	1.31 (1.52)	0.30 (1.14)	4.67 (2.38)
jaggery 1%	6.98 (2.82)	7.98 (3.00)	8.98 (3.16)	9.31 (3.21)	10.31 (3.36)	10.33 (3.37)	10.30 (3.36)	10.65 (3.41)	11.30 (3.51)	0.00 (1.00)	4.00 (2.24)	4.63 (2.37)	3.25 (2.06)	2.61 (1.90)	6.67 (2.76)
jaggery 0.5%	6.61 (2.76)	6.61 (2.76)	6.98 (2.82)	7.92 (2.99)	7.83 (2.97)	8.98 (3.16)	8.25 (3.04)	8.87 (3.14)	9.26 (3.20)	0.00 (1.00)	2.32 (1.82)	4.32 (2.31)	2.82 (1.95)	1.31 (1.52)	5.41 (2.53)
jaggery 0.25%	5.98 (2.64)	6.98 (2.82)	8.00 (3.00)	6.28 (2.70)	6.94 (2.82)	7.98 (3.00)	8.59 (3.10)	8.95 (3.15)	9.30 (3.21)	0.00 (1.00)	0.00 (1.00)	1.59 (1.61)	1.31 (1.52)	0.30 (1.14)	4.46 (2.34)
toddy 100%	2.65 (1.91)	1.31 (1.52)	1.64 (1.63)	1.21 (1.49)	1.31 (1.52)	0.00 (1.00)	2.32 (1.82)	0.00 (1.00)	1.31 (1.52)	1.64 (1.63)	0.63 (1.28)	1.64 (1.63)	1.64 (1.63)	0.00 (1.00)	1.16 (1.47)
toddy 50%	0.00 (1.00)	0.00 (1.00)	1.31 (1.52)	1.31 (1.52)	1.64 (1.63)	0.63 (1.28)	0.00 (1.00)	0.00 (1.00)	0.63 (1.28)	1.00 (1.41)	1.21 (1.49)	2.00 (1.73)	1.31 (1.52)	0.00 (1.00)	0.72 (1.31)
toddy 25%	4.63 (2.37)	5.66 (2.58)	4.32 (2.31)	1.31 (1.52)	2.32 (1.82)	1.31 (1.52)	3.65 (2.16)	4.66 (2.38)	3.65 (2.16)	1.94 (1.72)	1.94 (1.72)	2.65 (1.91)	2.65 (1.91)	0.00 (1.00)	2.74 (1.93)
<u>bittergourd fruits</u>															
,, 4 days old	5.98 (2.64)	1.94 (1.72)	1.94 (1.72)	0.63 (1.28)	1.59 (1.61)	2.61 (1.90)	2.32 (1.82)	2.82 (1.95)	4.18 (2.28)	1.64 (1.63)	0.63 (1.28)	0.30 (1.14)	0.91 (1.38)	0.00 (1.00)	1.78 (1.67)
,, 6 days old	3.65 (2.16)	2.61 (1.90)	2.65 (1.91)	2.22 (1.79)	2.55 (1.88)	3.86 (2.20)	4.26 (2.29)	3.65 (2.16)	4.26 (2.29)	2.96 (1.99)	0.63 (1.28)	1.00 (1.41)	0.30 (1.14)	0.00 (1.00)	2.30 (1.82)
,, 8 days old	2.22 (1.79)	2.26 (1.80)	3.25 (2.06)	3.58 (2.14)	2.22 (1.79)	1.94 (1.72)	2.65 (1.91)	1.64 (1.63)	0.00 (1.00)	1.64 (1.63)	2.00 (1.73)	0.63 (1.28)	1.00 (1.41)	0.00 (1.00)	1.67 (1.64)
,, ripe	9.66 (3.27)	9.63 (3.26)	10.31 (3.36)	10.94 (3.46)	9.17 (3.19)	10.91 (3.45)	12.65 (3.69)	14.33 (3.92)	14.33 (3.92)	7.31 (2.88)	8.98 (3.16)	4.63 (2.37)	3.62 (2.15)	1.94 (1.72)	8.78 (3.13)

figures in parentheses are transformed values $\sqrt{x + 1}$

Note: vinegar tried at 20, 10 and 5% showed slight attraction upto 90 minutes only and hence the data were not included in the statistical analysis.

C.D. for comparing mean = 0.24

C.D. for comparing the number of flies attracted at different periods of exposure = 0.08

C.D. for comparing treatments = 0.33

numbers being 5.90, 5.41 and 4.48 respectively. At the lowest concentration 0.25 per cent honey (4.67) and jaggery (4.46) came on par while sugar with a mean number of 3.52 flies was significantly inferior to honey though it came on par with jaggery. The middle concentration of honey came on par with the higher concentrations of jaggery and sugar and the results indicated that honey was the best of the three treatments.

Toddy was not found to be effective for trapping D. cucurbitae. The lowest concentration of 25 per cent was most attractive and even in that treatment the mean number of flies settled was 2.74 per observation only. The response and doses did not show a positive or negative association. The middle concentrations of 50 per cent was least attractive with the minimum mean number of 0.72 flies per observation while the highest concentration of 100 per cent attracted 1.16 number of flies.

Immature stages of bittergourd also were less attractive to the flies, the mean numbers attracted by 4, 6 and 8 day old fruits being 1.78, 2.30 and 1.67 respectively.

When the treatments were ranked for each of the fourteen observations ripe bittergourd came in the first, third, fourth and fifth positions in 10, 2, 1 and 1 observations respectively

Table 2. Field evaluation of attractants for baiting the adults of *D. cucurbitae*

attractants used and concentrations	mean number of flies attracted at different intervals after exposure (days)				mean
	1	2	3	4	
jaggery 1%	11.49 (3.39)	11.76 (3.43)	11.76 (3.43)	11.76 (3.43)	11.70 (3.42)
sugar 1%	8.64 (2.94)	17.56 (4.19)	17.98 (4.24)	18.32 (4.28)	15.29 (3.91)
honey 1%	15.84 (3.98)	24.60 (4.96)	25.60 (5.06)	26.32 (5.13)	22.84 (4.78)
toddy 25%	12.04 (3.47)	17.39 (4.17)	18.49 (4.30)	18.92 (4.35)	16.56 (4.07)
vinegar 20%	9.49 (3.08)	10.18 (3.19)	10.18 (3.19)	10.18 (3.19)	9.99 (3.16)
ripe bitter-gourd fruits	11.90 (3.45)	14.14 (3.76)	15.21 (3.90)	15.52 (3.94)	14.14 (3.76)

figures in parentheses are transformed values $\sqrt{x}$

C.D. for comparing treatments = 0.070

C.D. for comparing means = 0.44

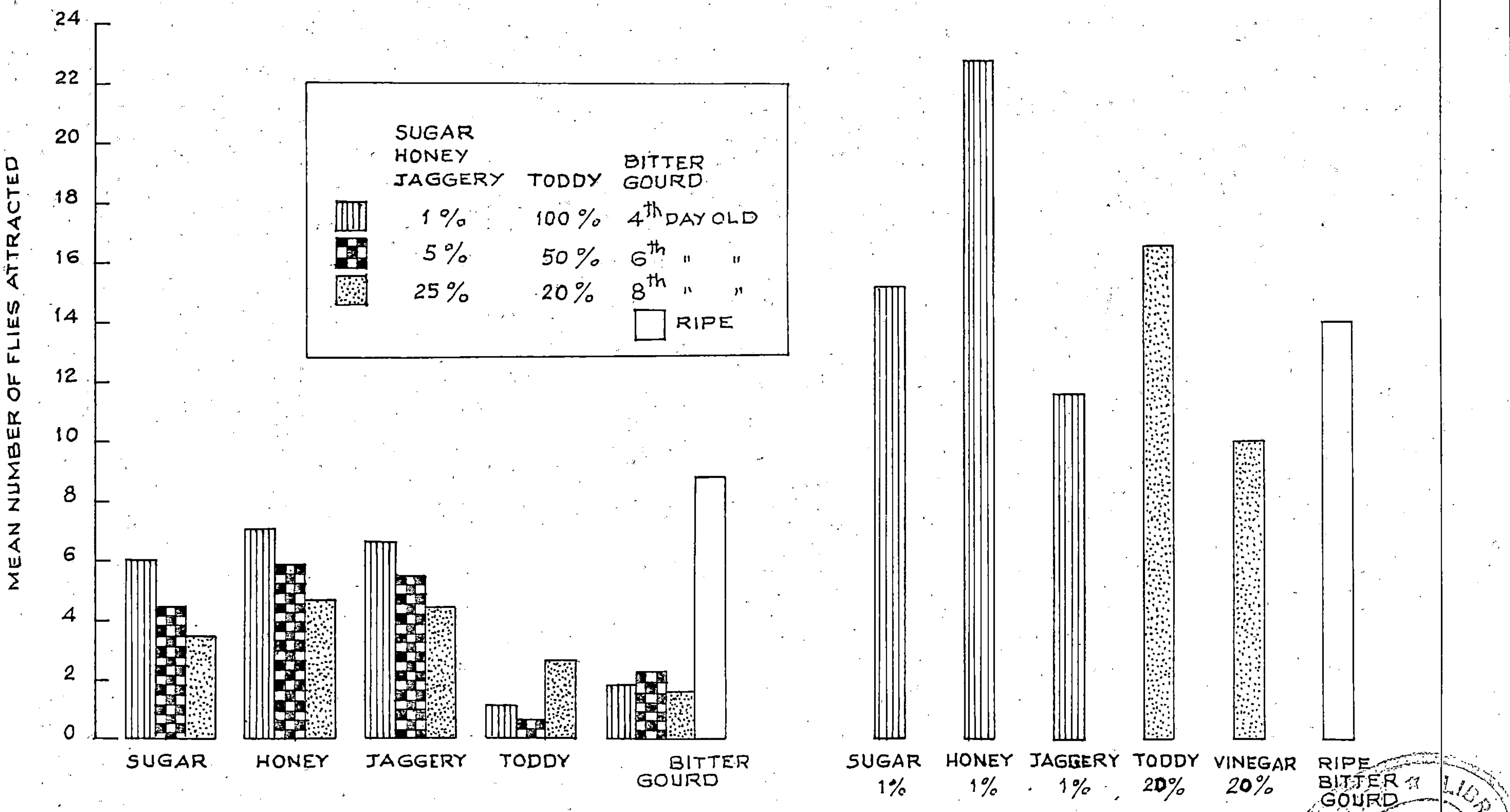
Honey came in first, second, third, fourth and eighth positions in 2, 3, 6, 2 and 1 observations respectively. In the case of jaggery it came in the second, third, fourth, sixth and fourteenth positions in 5, 4, 3, 1 and 1 observations. Sugar came first, second, fourth, fifth, seventh, ninth and tenth positions in 1, 5, 1, 2, 2, 1 and 2 observations respectively. In general ripe bittergourd fruits ranked higher than other treatments upto 12 hours of exposure. At 24 hours after exposure sugar, honey and jaggery ranked higher than bitter gourd fruits. Thus the persistent effect was seen more for honey, jaggery and sugar than for bittergourd fruits.

4.2. Field evaluation of the selected attractants for baiting the adults of *D. cucurbitae*

The data relating to the experiment and the results of statistical analysis of the same are presented in Table 2. The results showed that honey 1 per cent was significantly superior to all other treatments in attracting the flies in the field as observed on the first, second, third and fourth days after exposure (15.84, 24.60, 25.60 and 26.32 respectively) and also in the mean numbers computed (22.84). The mean catch in baits using toddy (16.56), sugar (15.29) and ripe bittergourd fruits (14.14) were on par but significantly inferior to honey. Among the three treatments sugar and

Fig. 1. Relative efficacy of different attractants for trapping *D. cucurbitae* used in different concentrations as observed in laboratory screening.

Fig. 2. Relative efficacy of different attractants for trapping *D. cucurbitae* observed in replicated field experiment.



MEAN NUMBER OF FLIES ATTRACTED
0
2
4
6
8
10
12
14
16
18
20
22
24
SUGAR
HONEY
JAGGERY
TODDY
BITTER GOURD
SUGAR HONEY JAGGERY
TODDY
BITTER GOURD
1 %
100 %
4th DAY OLD
5 %
50 %
6th " "
25 %
20 %
8th " "
RIPE
SUGAR 1%
HONEY 1%
JAGGERY 1%
TODDY 20%
VINEGAR 20%
RIPE BITTER GOURD

toddy were on par and significantly superior to bittergourd fruits in the observations recorded on the second, third and fourth days after exposure of the baits. Jaggery and vinegar were found as less effective in all the observations though the former came on par with bittergourd fruits in the mean values.

As shown in Fig. 1 and 2 ripe bittergourd fruits which showed the highest attractiveness in the laboratory was found inferior to honey in field evaluation. Toddy had a better performance in the field than in the laboratory. Similarly vinegar which failed to show significant attractiveness to the flies in the laboratory showed significant attractiveness in the field, the mean number of flies caught being in the range of 9.49 to 10.18 in comparison with the mean number of 15.84 to 26.32 in the best treatment viz. honey. Thus the results obtained in the laboratory and field showed significant variations.

4.3. Attctiveness of different varieties of banana and honey to the adults of *D. cucurbitae*

Data relating to the experiment and results of statistical analysis of the same are presented in Table 3. Data showed that one per cent honey (mean flies caught 20.07) and plalyankodan fruits cut crosswise (23.14) were on par and the latter

Table 3. Comparative efficacy of different varieties of banana fruits and honey as attractants for baiting adults of D. cucurbitae

treatments	mean number of flies attracted at different intervals after exposure (days)				mean
	1	2	3	4	
nendran - cut lengthwise	6.30 (2.51)	9.30 (3.05)	10.30 (3.21)	10.69 (3.27)	9.06 (3.01)
nendran - cut crosswise	6.60 (2.57)	8.64 (2.94)	10.63 (3.26)	11.63 (3.41)	9.30 (3.05)
poovan - cut lengthwise	10.63 (3.26)	12.96 (3.60)	15.52 (3.94)	16.89 (4.11)	13.91 (3.73)
poovan - cut crosswise	10.96 (3.31)	11.97 (3.46)	13.99 (3.74)	15.68 (3.96)	13.10 (3.62)
palayankodan - cut lengthwise	13.84 (3.72)	18.23 (4.27)	22.94 (4.79)	23.62 (4.86)	19.45 (4.41)
palayankodan - cut crosswise	16.65 (4.08)	22.66 (4.76)	26.63 (5.16)	27.67 (5.26)	23.14 (4.81)
raskadali - cut lengthwise	6.66 (2.58)	9.00 (3.00)	10.63 (3.26)	10.96 (3.31)	9.24 (3.04)
raskadali - cut crosswise	6.30 (2.51)	7.34 (2.71)	7.95 (2.82)	8.29 (2.88)	7.45 (2.73)
honey 1%	15.84 (3.98)	19.36 (4.40)	21.25 (4.61)	24.30 (4.93)	20.07 (4.48)

figures in parentheses are transformed values $\sqrt{x}$

C.D. for comparing treatments = 0.10

C.D. for comparing means = 0.38

came on par with palayankodan fruits cut lengthwise (19.45) also. The above treatments were followed by poovan fruits cut lengthwise and crosswise (13.91 and 13.10 respectively) which were on par. Nendran and rasakadali fruits (catch 7.45 to 9.30) were least effective and on par.

One day after setting the trap palayankodan fruits cut crosswise came on par with honey while in the remaining observations the former was significantly superior to the latter. The palayankodan fruits cut lengthwise was seen inferior to the fruits cut crosswise at the first and second days after setting the traps while the treatment honey came on par with palayankodan cut lengthwise on the third and fourth days after the exposure. In three of the four observations lengthwise cut was found significantly better than crosswise cut in the case of poovan and rasakadali while in one they were on par. In the case of nendran the trend was not constant in the four observations.

4.4. Relative susceptibility of different varieties/ accessions of bittergourd grown at NBPGR, Vellanikkara, Trichur

Results of the experiment and the inferences of statistical analysis of the data are presented in Table 4. Based on the mean percentage of infested fruits observed

Table 4. Relative susceptibility of different varieties/accessions of bittergourd to D. cucurbitae

varieties/ accessions	mean percentage of infested fruits (number) observed at different intervals after planting (weeks)			mean	remarks
	8	9	10		
NBPGR accession No.					
6	16.88(24.24)	0.00(0.00)	13.21(21.30)	10.03(18.44)	R
7	12.52(20.71)	19.93(26.51)	21.20(27.41)	17.88(25.01)	MR
12	12.33(20.54)	9.25(17.71)	58.16(49.70)	26.58(31.02)	S
13	16.57(24.01)	43.00(40.95)	35.49(36.54)	31.68(34.23)	S
15	0.68(4.72)	19.32(26.04)	66.98(54.92)	28.99(32.54)	S
17	22.99(28.63)	30.73(33.64)	18.50(25.44)	24.07(29.35)	MR
17B	0.00(0.00)	7.98(16.41)	12.90(21.03)	6.96(15.25)	R
19	20.01(26.54)	14.23(22.14)	22.59(28.34)	18.94(25.80)	MR
21	0.00(0.00)	28.79(32.43)	46.28(42.84)	25.02(30.00)	MR
21W	0.52(4.12)	29.33(32.75)	41.85(40.31)	23.90(29.24)	MR
22	9.85(18.25)	50.27(45.14)	65.26(53.84)	41.79(40.24)	HS
22A	14.75(22.55)	33.92(35.61)	72.50(58.34)	40.39(39.44)	HS
27A	3.62(10.94)	17.08(24.40)	49.99(44.95)	23.56(29.02)	MR
28	8.48(16.92)	39.48(38.91)	62.49(52.21)	36.82(37.33)	S
34	4.02(11.53)	34.62(36.02)	51.45(45.82)	30.03(33.21)	S
35	1.28(6.50)	20.90(27.20)	23.12(28.72)	15.10(22.84)	MR
36	4.64(12.42)	17.52(24.72)	48.09(43.89)	23.42(28.92)	MR
42	4.50(12.23)	20.07(26.61)	29.85(33.11)	18.14(25.20)	MR
45	7.03(15.34)	29.37(32.81)	24.11(29.40)	20.17(26.65)	MR
50	3.45(10.70)	41.89(40.33)	41.68(40.20)	29.01(32.55)	S
61W	4.38(12.05)	39.80(39.11)	40.90(39.73)	28.36(32.14)	S
61G	3.24(10.34)	29.59(32.93)	23.56(29.14)	18.80(25.70)	MR
67	4.42(12.12)	41.32(40.00)	14.29(22.21)	20.01(26.54)	MR
67A	27.96(31.92)	49.95(44.94)	50.02(45.01)	42.64(40.74)	HS
72A	28.71(32.39)	24.39(29.60)	44.43(41.80)	32.51(34.74)	S
74G	27.06(31.32)	31.12(33.89)	41.32(40.00)	33.17(35.14)	S
74W	20.87(27.15)	50.08(45.03)	59.22(50.30)	43.39(41.20)	HS
76A	6.82(15.12)	55.07(47.90)	30.37(33.42)	30.75(33.64)	S
78A	2.62(9.31)	38.44(38.31)	52.71(46.53)	31.26(33.95)	S
78C	4.35(12.02)	17.63(24.81)	33.91(35.61)	18.63(25.54)	MR
80	4.47(12.20)	32.46(34.72)	23.98(29.95)	20.30(26.75)	MR
83	11.23(19.55)	22.68(28.42)	9.78(18.21)	14.56(22.42)	MR
85	8.66(17.11)	21.14(27.35)	36.51(37.14)	22.10(28.03)	MR
86	6.79(15.10)	44.64(41.91)	54.31(47.44)	35.25(36.41)	S
87	14.62(22.44)	27.69(31.72)	60.04(50.75)	34.12(35.72)	S
103	10.56(18.94)	51.34(45.74)	56.73(48.84)	39.54(38.93)	HS
104	16.81(24.20)	9.55(18.00)	44.44(41.75)	23.60(29.04)	MR
108	7.21(15.55)	15.58(23.23)	51.98(46.12)	24.92(29.93)	MR
116	0.45(3.81)	38.06(38.05)	27.16(31.41)	21.89(27.90)	MR
125	4.31(11.95)	17.46(24.70)	26.68(31.10)	16.15(23.69)	MR
128	17.21(24.50)	13.27(21.33)	34.04(35.65)	21.51(27.62)	MR
139	19.25(26.01)	20.00(26.54)	4.01(11.53)	14.42(22.31)	MR
141	27.95(31.91)	15.96(23.53)	23.45(28.94)	22.45(28.25)	MR
145	5.85(14.00)	3.17(10.23)	35.72(36.69)	14.91(22.71)	MR
148	6.51(14.73)	22.32(28.15)	37.90(38.00)	22.24(28.12)	MR
175	12.47(20.65)	53.61(47.03)	78.46(62.32)	48.18(43.94)	HS
priya	23.54(29.01)	26.85(31.21)	23.14(28.73)	24.51(29.65)	MR

C.D. for comparing mean = 2.877 C.D. for comparing treatment = 0.844
MBPGR: National Bureau of Plant Genetic Resources
figures in parentheses are transformed values (angles)

HR: highly resistant R: resistant MR: moderate resistant S: susceptible
HS: highly susceptible

over three harvests, the accessions were grouped into five categories. The accessions 6 and 17B came in the resistant group (R) and the percentage of infestations were 10.03 and 6.96 respectively.

Accessions 139 (14.42), 83 (14.56), 145 (14.91), 35 (15.10), 125 (16.15), 7 (17.88), 42 (18.14), 61G (18.80), 78C (18.63), 19 (18.94), 67 (20.01), 45 (20.17), 80 (20.30), 128 (21.51), 116 (21.89), 85 (22.10), 148 (22.24), 141 (22.45), 36 (23.42), 27A (23.56), 104 (23.60), 21W (23.90), 17 (24.07), priya (24.51), 108 (24.92) and 21 (25.02) were found to be moderately resistant (MR).

Accessions 12 (26.58), 61W (28.36), 15 (28.99), 50 (29.01), 34 (30.03), 76A (30.75), 78A (31.26), 13 (31.68), 74G (33.17), 87 (34.12), 86 (35.25) and 28 (36.82) came in the susceptible group (S).

Remaining accessions, 103 (39.54), 22A (40.39), 22 (41.79), 67A (42.64), 74W (43.39) and 175 (48.18) were found highly susceptible (HS).

Among the resistant varieties/accessions, 17B showed the least infestation and it was significantly lower than the infestation observed in accession 6.

Among the moderately resistant accessions 139, 83, 145, 35, 125 and 7 were on par. Accession 7 was followed by 42, 61G, 78C, 19, 67, 45, 80, 128, 116 and 85 and they were on par. Remaining accessions came on par with the susceptible check Priya. Accessions 108 and 21 were the least resistant in this group. The two resistant accessions 17B and 6, three accessions 83, 35 and 7 from the first group and moderately resistant accessions and accessions 19 and 80 from the second group of moderately resistant ones were selected for further evaluation under field conditions.

4.5. Relative susceptibility of selected varieties/ accessions of bittergourd to *D. cucurbitae*

The data relating to the experiment and results of statistical analysis of the same are presented in Table 5 and 6 and Fig. 3.

The accessions NBPGR 6 and 17B which were found to be resistant in the initial screening came in the MR group in the replicated field experiment, the mean percentage of infested fruits being 14.39 and 17.22 respectively. Accession 35 showed low infestation (10.37%) and came in the resistant group. Two of the four new accessions added in this experiment viz. 239 and 271 also came in the R group, the percentage infestation being 5.84 and 7.26 respectively.

Table 5. Relative susceptivity of selected varieties of bitter gourd to D. cucurbitae

varieties used		yield	mean percentage of infested fruits (number observed at different intervals after planting (weeks					mean	remarks
			8	9	10	11	12		
local greenish white		104.60	21.17 (27.39)	10.61 (19.00)	8.46 (16.90)	21.43 (27.55)	31.47 (34.11)	18.63 (25.54)	MR
local green		94.60	28.03 31.94	13.26 21.33	17.31 24.55	17.56 24.74	23.46 28.94	19.92 26.49	MR
priya		212.00	33.00 (35.04)	15.64 (23.30)	15.80 (23.42)	14.10 (22.03)	28.83 (32.44)	21.47 (27.60)	MR
NBPGR	6	156.67	27.54 (30.33)	9.92 (18.34)	7.37 (15.73)	4.03 (11.54)	23.10 (28.71)	14.39 (22.25)	MR
,,	7	185.67	18.97 (25.81)	15.81 (23.42)	8.85 (17.30)	9.23 (17.65)	30.01 (33.21)	16.57 (24.01)	MR
,,	17B	239.00	17.52 (24.73)	12.39 (20.60)	8.71 (17.14)	15.58 (23.23)	31.88 (34.34)	17.22 (24.51)	MR
,,	19	198.33	24.08 (29.37)	12.54 (20.72)	8.10 (16.52)	9.89 (18.31)	30.89 (33.74)	17.10 (24.42)	MR
,,	35	172.66	15.22 (22.95)	5.34 (13.34)	4.40 (12.11)	14.18 (22.11)	12.72 (20.90)	10.37 (18.77)	R
,,	80	226.30	26.64 (31.05)	11.90 (20.15)	7.79 (16.21)	8.80 (17.23)	23.84 (29.21)	15.79 (23.41)	MR
,,	83	145.67	19.04 (25.84)	7.35 (15.72)	9.63 (18.05)	13.14 (21.23)	21.21 (27.41)	14.07 (22.02)	MR
,,	239	144.33	9.39 (17.83)	1.45 (6.91)	8.61 (17.04)	2.04 (8.21)	7.71 (16.11)	5.84 (13.95)	R
,,	244	210.00	17.94 (25.03)	14.44 (22.32)	5.84 (13.95)	9.93 (18.34)	18.06 (25.13)	13.24 (21.32)	MR
,,	261	249.33	18.86 (25.72)	13.47 (21.52)	9.27 (17.71)	11.27 (19.61)	22.63 (28.40)	15.10 (22.84)	MR
,,	271	109.00	9.19 (17.62)	0.36 (3.42)	4.46 (12.15)	2.30 (8.71)	20.01 (26.54)	7.26 (15.62)	R

C.D. for comparing varieties at different periods = 2.69
C.D. for comparing means = 3.47
NBPGR - National Bureau of Plant Genetics Resources
MR - moderate resistant
R - resistant
Figures in parentheses are transformed values (angles)

Table 6. Relative susceptibility of selected varieties of bitter gourd to D. cucurbitae

varieties used		yield	mean percentage of infested fruits (weight) observed at different intervals after planting (weeks)					mean	remarks
			8	9	10	11	12		
local greenish white		926.67	20.84 (27.14)	25.93 (30.59)	20.69 (27.03)	37.13 (37.52)	65.10 (53.75)	33.94 (33.62)	S
local green		789.33	36.40 (37.11)	22.01 (27.95)	35.44 (36.52)	39.05 (38.64)	52.78 (46.55)	37.24 (37.60)	S
priya		1776.00	42.41 (40.62)	11.44 (19.74)	9.34 (17.80)	12.21 (20.43)	29.76 (33.04)	21.03 (27.30)	MR
NBPGR	6	1261.33	34.15 (33.74)	11.75 (20.03)	17.58 (24.75)	27.83 (31.82)	34.32 (35.83)	25.13 (30.05)	S
,,	7	1582.67	9.33 (17.75)	11.08 (19.42)	7.93 (16.33)	13.44 (21.50)	16.26 (23.75)	11.61 (19.91)	R
,,	17B	2088.00	11.46 (19.75)	7.44 (15.82)	8.41 (16.84)	7.66 (16.04)	32.16 (34.53)	13.43 (21.50)	MR
,,	19	1349.33	36.40 (37.11)	8.03 (16.44)	6.96 (15.25)	8.45 (16.90)	21.79 (27.81)	16.33 (23.80)	MR
,,	35	1342.67	20.74 (27.05)	3.50 (10.75)	9.60 (18.03)	5.50 (13.54)	22.15 (28.04)	12.30 (20.52)	MR
,,	80	1544.00	36.67 (37.24)	20.20 (26.70)	18.42 (25.41)	26.32 (30.84)	28.63 (32.33)	26.05 (30.65)	S
,,	83	1341.33	23.13 (28.73)	13.72 (21.72)	18.69 (25.61)	12.41 (20.62)	38.92 (38.60)	21.37 (27.52)	MR
,,	239	1471.33	13.62 (21.63)	8.27 (16.71)	7.74 (16.13)	5.53 (13.60)	7.85 (16.24)	8.60 (17.03)	R
,,	244	776.67	3.94 (11.42)	1.38 (6.73)	3.68 (11.04)	3.51 (10.80)	12.71 (20.85)	5.04 (12.94)	R
,,	261	1082.67	25.51 (30.32)	8.73 (17.15)	5.97 (14.12)	4.96 (12.84)	14.26 (22.15)	11.89 (20.14)	R
,,	271	1037.33	15.10 (22.84)	23.54 (29.01)	10.04 (18.44)	12.45 (20.64)	25.81 (30.52)	17.39 (24.63)	MR
C.D.			NS	NS	NS	NS	NS	2.829	

NS: not significant
MBPGR: National Bureau of Plant Genetic Resources
S: susceptible
R: resistant
MR: moderate resistant
figures in parentheses are transformed values (angles)

Based on the CD values the accessions 239 (5.84) and 271 (7.26) came on par followed by 35 (10.37) which came under the resistant (R) group. Accession 35 was on par with 244 (13.24) and 83 (14.07). Accessions 6 (14.39), 261 (15.10), 80 (15.79), 7 (16.57), 19 (17.10) and 17B (17.22) came on par and they were on par with accession 83 also. Accession 17B along with LGW and LG came on par with the susceptible check Priya which showed the highest infestation (21.47%).

Of the six accessions ranked, the best accessions 239 and 271 were on par and ranked top during the 1st harvest done at 8th week after planting and in the 4th harvest. During 2nd harvest 271 ranked first and was significantly superior to accession 239. In the third harvest 271 ranked higher than 239 whereas in the 5th harvest 239 ranked higher than 271 and the differences between them were statistically significant. These accessions were immediately followed by accession 35, in the 1st and 5th harvest and in the 3rd harvest; 35 came as the 1st in the second harvest and it came on par with 271, but in the 4th harvest it came on par with the check and came in the 11th place.

The accession 244 was significantly inferior to 239 and 271 in the mean values and also in the 1st and 4th harvests and it came on par with susceptible check Priya in the 2nd harvest. During the 5th harvest it came significantly inferior to 239 and 35 and during the 3rd harvest it came on par with 35 and 271.

In general accessions 83 and 6 were coming in an intermediate position in the different harvests. The relative rank of accession 83 in the five harvests were 8th, 4th, 12th, 9th and 5th respectively. The ranks of accession 6 in the different harvests were 12th, 5th, 4th, 3rd and 7th respectively.

The data relating to the relative susceptibility of the different accessions based on the weight of fruits harvested are presented in Table 6. The mean of the five different harvests showed that accession 244 was the best in which the infestation per cent was 5.04 only. It was followed by accession 239 (8.6) and the two accessions were significantly superior to all other accessions/varieties. The accession 7 (11.61), 261 (11.89), 35 (12.30) and 17B (13.43) came on par and followed the accession 239 (Fig. 3).

Accession 244 maintained its superiority over all the other treatments in the 1st, 2nd, 3rd and 4th harvests. During the 5th harvest it ranked second and inferior to accession 239 only. But accession 239 though inferior only to 244, when the means were compared, it ranked 4th in the 1st, 3rd and 4th harvests and 5th in the 2nd harvest. It occupied the 1st position in the 5th harvest.

Accession 7 maintained its position as 2nd in 1st harvest, 7th in 2nd harvest and 5th in third harvest. In the 4th harvest it went down to the 10th position, it came up to the 4th position in the last harvest.

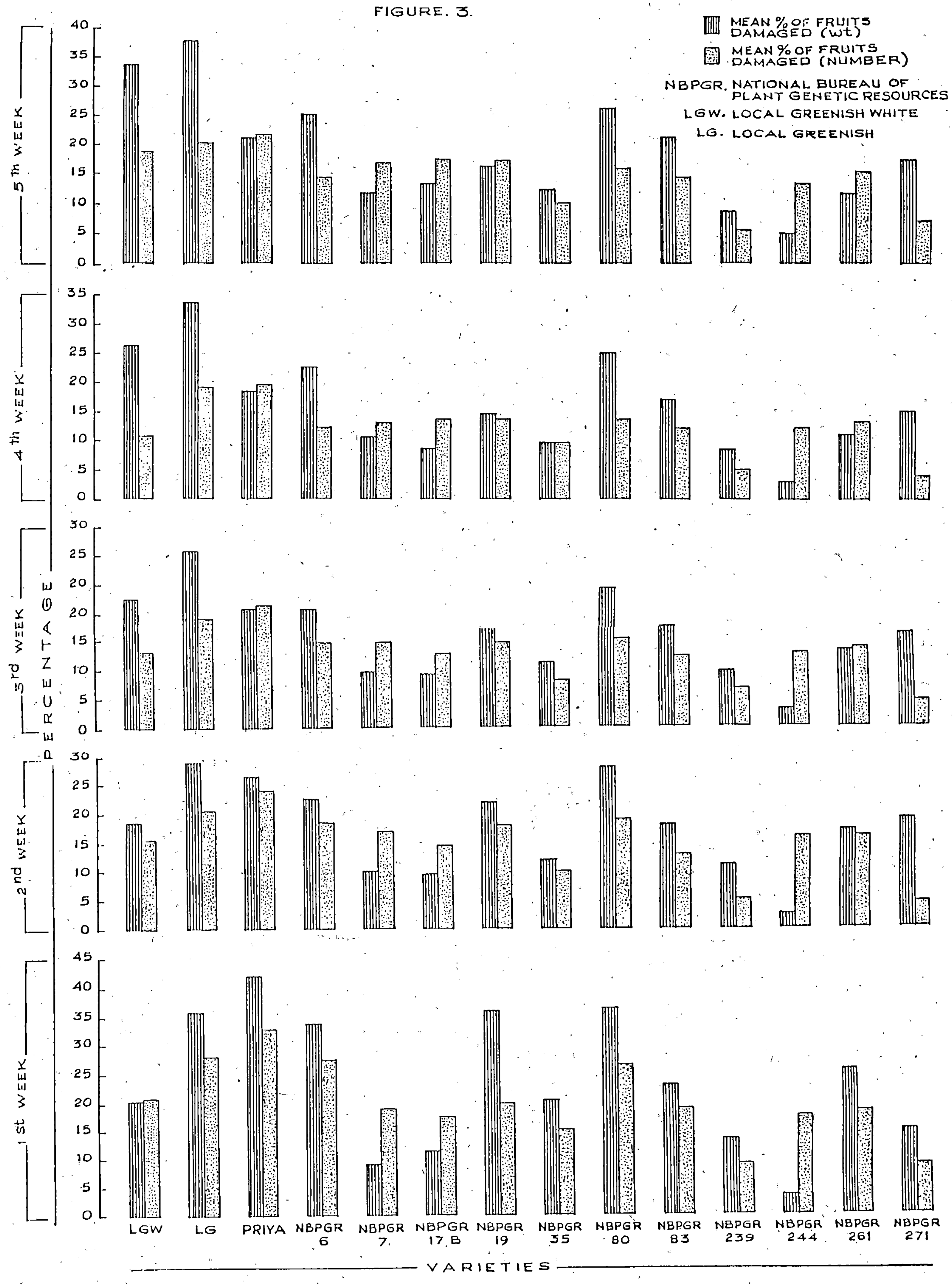
Accession numbers 261, 35 and 17B which ranked 4th, 5th and 6th while comparing the means, occupied 9th, 6th and 3rd positions, respectively in the 1st harvest. In the 2nd harvest the positions were altered to 6th, 2nd and 3rd, respectively. In the 3rd and 4th harvest 261 was 2nd in position inferior to 244 only while it came in the 3rd position in the 5th harvest. Accession number 35 ranked far below, in the 8th position, in the 3rd harvest, while it reached the 3rd position in the 4th harvest and 6th position in the 5th harvest. In the case of 17B it occupied the 6th, 5th and 10th positions in the 3rd, 4th and 5th harvest, respectively.

The accession 271, 83 and 6 which ranked high on the basis of percentage of infested fruits by number, came low in rank when the percentage of weight of fruits lost due to the pest infestation was taken into consideration and these accessions came on par with the check Priya. But on weight basis, the accessions 7, 261 and 17B were seen promising and significantly superior to the check.

In general accessions 239, 35 and 244 came as the promising ones adopting both the criteria of evaluation

Fig. 3. Relative susceptibility of different accessions/varieties of bittergourd to *D. cucurbitae* observed in replicated field experiment.

FIGURE. 3.


MEAN % OF FRUITS DAMAGED (wt)
MEAN % OF FRUITS DAMAGED (NUMBER)
NBPGR. NATIONAL BUREAU OF PLANT GENETIC RESOURCES
LGW. LOCAL GREENISH WHITE
LG. LOCAL GREENISH
PERCENTAGE
5 th WEEK
4 th WEEK
3 rd WEEK
2 nd WEEK
1 st WEEK
LGW
LG
PRIYA
NBPGR 6
NBPGR 7.
NBPGR 17.B
NBPGR 19
NBPGR 35
NBPGR 80
NBPGR 83
NBPGR 239
NBPGR 244
NBPGR 261
NBPGR 271
VARIETIES

(Fig. 3). The mean number of fruits obtained from these three varieties (Table 5) were 144.33, 172.66 and 210.0, respectively while the number obtained from check variety Priya was 212. The weight of fruits obtained from the accessions 239, 35 and 244 were 1471.33, 1342.67, 776.67 grams per plot, respectively as against a corresponding weight of 1776 gram per plot in the check variety Priya. Accession numbers 271, 83 and 6 which were showing good performance while considering the percentage damage on the basis of number of fruits, yielded 109, 145.67 and 156.67 fruits per plot which weighed 1037.33, 1341.3 and 1261.33 grams, respectively.

Accession numbers 7, 261 and 17B ranked top in the percentage of good fruits on the basis of weight and gave 185.67, 249.33 and 239 numbers, their weights being 1582.67, 1082.67 and 2088.0 grams, respectively.

4.6. Effect of different accessions/varieties of bittergourd on the development and survival of the growth stages of fruit flies

The data collected and the results of statistical analysis of the same are presented in Table 7 and Fig. 4.

The intensity of damage in the infested fruits and the effect of varieties on the development of insects were assessed as described in para 3.5. The results and the inferences on

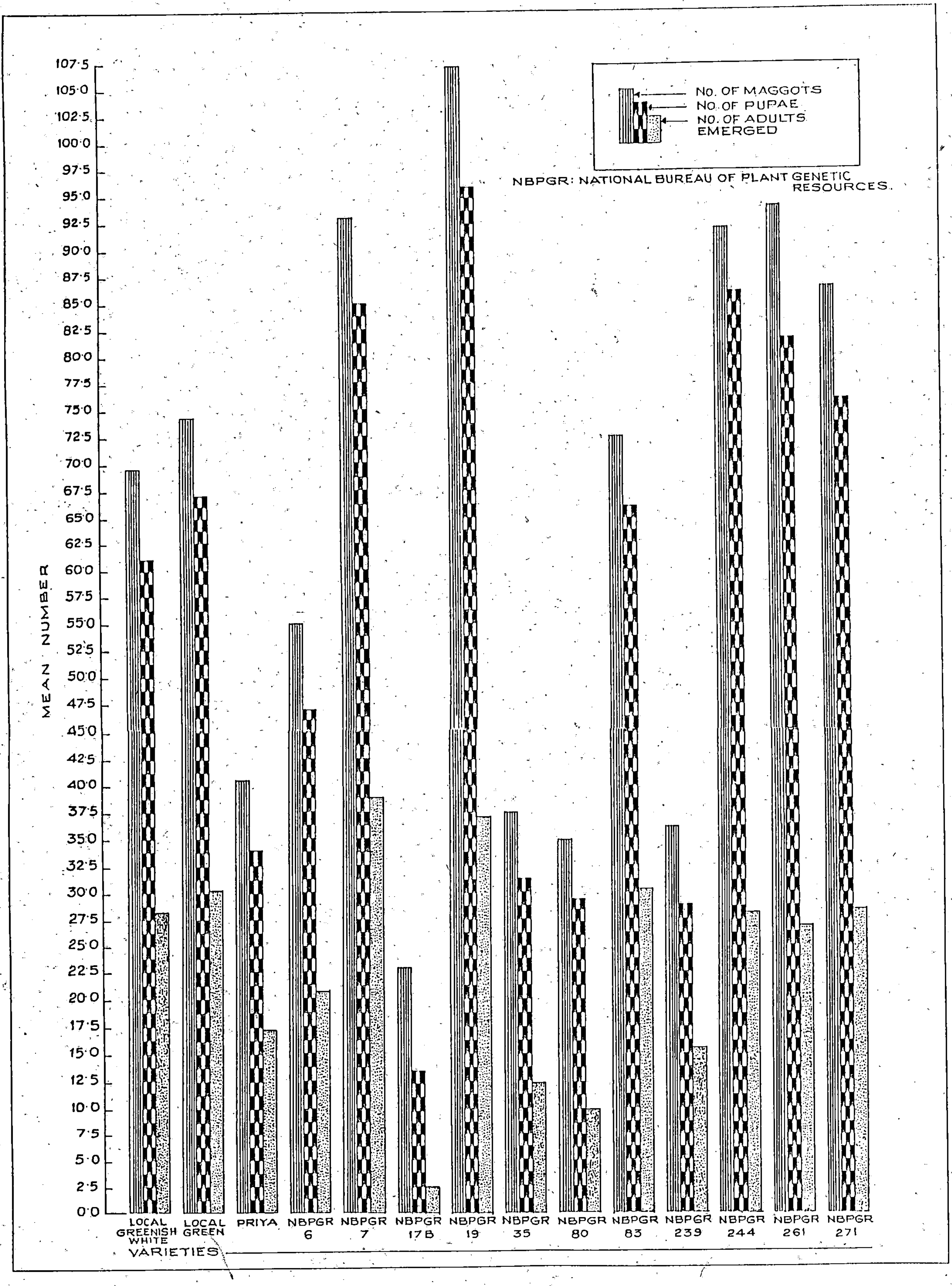
Table 7. Intensity of fruit damage caused by _D. cucurbitae_ in different varieties observed in 250g samples collected from field and stored in laboratory

varieties	number of full grown larvae	number of pupae	larval mortality during pupation	number of adult flies observed	pupal mortality percentage	number of female flies	sex ratio
local greenish white	69.61 (8.34)	60.95(7.81)	12.60(20.80)	28.26(5.32)	51.10(45.62)	5.90(2.43)	1:3.01
local green	74.30 (8.62)	67.53(8.22)	9.45(17.90)	30.30(5.50)	50.50(45.25)	15.52(3.94)	1:1.22
priya	40.52 (6.37)	34.43(5.87)	11.80(20.05)	17.27(4.16)	58.75(50.02)	5.65(2.38)	1:2.05
NBPGR 6	54.92 (7.41)	47.30(6.88)	12.60(20.80)	20.65(4.54)	60.40(51.00)	7.91(2.81)	1:0.98
7	92.88 (9.64)	84.87(9.21)	11.25(19.58)	38.91(6.24)	43.00(40.95)	10.33(3.21)	1:2.81
17B	23.07 (4.80)	13.46(3.67)	35.40(36.51)	2.49(1.58)	91.50(73.04)	1.63(1.28)	1:2.76
19	107.20(10.35)	96.61(9.83)	13.80(21.80)	37.26(6.10)	45.40(42.34)	16.96(4.12)	1:0.43
35	37.63 (6.13)	31.64(5.62)	12.75(20.91)	12.58(3.55)	69.75(56.62)	7.18(2.68)	1:1.66
80	34.88 (5.91)	29.57(5.44)	11.76(20.03)	11.39(3.37)	72.35(58.24)	7.84(2.80)	1:1.02
83	72.57 (8.52)	65.97(8.12)	9.50(17.93)	30.60(5.53)	50.15(45.08)	8.70(2.95)	1:0.50
239	36.27 (6.02)	29.31(5.41)	15.55(23.22)	15.86(3.98)	57.30(49.19)	5.71(2.39)	1:0.89
244	92.23 (9.60)	85.88(9.27)	9.15(17.60)	28.86(5.37)	55.50(48.13)	15.68(3.96)	1:1.94
261	93.90 (9.69)	81.51(9.03)	16.15(23.69)	26.87(5.18)	57.60(49.35)	13.25(3.64)	1:1.98
271	86.30 (9.29)	75.92(8.71)	14.15(22.10)	28.63(5.35)	54.90(47.81)	9.24(3.04)	1:0.86
C.D.	0.64	0.72	11.76	0.77	16.45	0.72	

figures in parentheses are transformed values $\sqrt{x}$ and angles for number and percentage respectively

NBPGR: National Bureau of Plant Genetic Resources

Fig. 4. Antibiosis manifested by different accessions/varieties of bittergourd against *D. cucurbitae*.



NO. OF MAGGOTS
NO. OF PUPAE
NO. OF ADULTS EMERGED
NBPGR: NATIONAL BUREAU OF PLANT GENETIC RESOURCES.
MEAN NUMBER
107·5
105·0
102·5
100·0
97·5
95·0
92·5
90·0
87·5
85·0
82·5
80·0
77·5
75·0
72·5
70·0
67·5
65·0
62·5
60·0
57·5
55·0
52·5
50·0
47·5
45·0
42·5
40·0
37·5
35·0
32·5
30·0
27·5
25·0
22·5
20·0
17·5
15·0
12·5
10·0
7·5
5·0
2·5
0·0
LOCAL GREENISH WHITE
LOCAL GREEN
PRIYA
NBPGR 6
NBPGR 7
NBPGR 17B
NBPGR 19
NBPGR 35
NBPGR 80
NBPGR 83
NBPGR 239
NBPGR 244
NBPGR 261
NBPGR 271
VARIETIES

the statistical analysis of the data are presented in Table 7. The lowest number of maggots was observed in accession 17B (23.07). This was significantly superior to all other accessions followed by the accessions 80, 239, 35 and the check (Priya). These were on par among themselves (34.88 to 40.52). Accession 6 (54.92) was following Priya and it was significantly lower than the remaining accessions. Accession 19 showed the maximum number of maggots (107.20), the other accessions remaining in between.

Regarding the number of pupae also acession 17B (13.46) came on par with 239 (29.31) and the latter came on par with accessions 80 (29.57), 35 (31.64) and Priya (34.43) which were on par. Other accessions came significantly inferior to the check variety Priya.

Accession 17B showed the highest larval mortality 35.40 per cent and it was significantly higher than the mortality in rest of the varieties. All the remaining varieties came on par with reference to this criterion.

The number of adults emerging from the fruits was found to be least in 17B (2.49). This accession was followed by 80, 35 and 239 which were on par. Accession 239 came on par with Priya and accession 6. The remaining accessions were far inferior (26.87 to 38.9 number of adults).

The pupal mortality was significantly higher in accession 17B (91.5 per cent). This was on par with accessions 80 and 35 (72.35 and 69.75). These were significantly superior to all other accessions. In the remaining accessions pupal mortality ranged from 43 to 60.40 per cent and they came on par.

The female emergence was least in 17B (1.63). But it was on par with the emergence in the check variety Priya. Accessions 239, LGW, 35, 8, 6, 83 and 271 were on par and also on par with Priya.

4.7. Protecting the growing fruits of bittergourd from egg laying of *D. cucurbitae* through bagging

An observational trial was carried out for evaluating the efficacy of different types of bags (paper, cloth and polythene) for protecting bittergourd fruits from the egg laying of *D. cucurbitae*. The results of the experiment are presented in Table 8. It was observed that paper bag and cloth bag used immediately after fruit set did not completely protect the fruits from the egg laying by the flies. Among fruits covered with paper bag 26.67 per cent and 40 per cent of the fruits enclosed in cloth bags were seen damaged by the maggots while 73.33 per cent of the fruits in unprotected control were attacked by the fly. The fruits covered with polythene bags were completely protected from the egg laying of *D. cucurbitae* and subsequent damage by the emerging maggots.

Table 8. Effect of bagging the growing fruits of bittergourd on the incidence of D. cucurbitae and on the growth of fruits

treatments	percentage fruit attacked (number)	length/ healthy fruit at harvest (cm)	girth/ healthy fruit at harvest (cm)	weight/ healthy fruit at harvest (g)
paper bag	26.67	23.31	11.31	87.50
cloth bag	40.00	19.69	9.93	62.50
polythene bag	nil	23.44	11.01	90.00
control	73.33	19.25	9.12	67.50

The mean lengths of healthy fruits protected in paper, cloth and polythene bags were 23.31, 19.69 and 23.44 cm respectively as against the mean length of 19.25 cm recorded for the uninfested fruits in control. The girth of bagged uninfested fruits ranged from 9.93 to 11.31 cm while in control the girth was 9.12 cm. The mean weights of uninfested fruits maintained in paper bag, cloth bag and polythene bag were 87.5, 62.5 and 90.0 grams respectively.

The cost benefit in adopting the mechanical protection of bittergourd fruits against *D. cucurbitae*, using different types of bags, had been worked out in detail and presented in Table 9. The net additional income that would be generated by bagging the fruits using polythene bags amounts to Rs.13697/ha while corresponding income from plots protected with paper bags would be Rs.7235/- only. The cloth bag, by virtue of its high cost was not found economical. There is no additional income from this treatment.

4.8. Effect of varying periods of protecting bittergourd fruits from the time of fruit set on the extent of damage caused by *D. cucurbitae*

The results of the experiment and inference from the statistical analysis of the data are presented in Table 10. The results showed that the fruits protected up to 5 days

Table 9. Cost benefit in adopting mechanical protection of bitter gourd fruits against D. cucurbitae

treatments	total yield		total additional yield over control	additional income (Rs.)	cost		net additional income (Rs.)
	wt/ha	no. /ha			materials (Rs.)	labour (Rs.)	
paper bag	6795	77657	4889	14667	1552	5880	7235
cloth bag	3971	63540	1265	3795	4236	4347	--
polythene bag	9531	105900	7625	22875	2824	6354	13697
control	1906	28244	--	--	--	--	--

1. No. of paper bags required/ha was calculated at the rate of one bag per fruit. The cost of the bag was 2 paise per bag.

2. No. of cloth bags required/ha was estimated on the basis that the bags could be reused in alternate weeks during the harvest period and they would last for three seasons. The cost was 50 paise per bag.

3. Polythene bags could be reused as in the case of cloth bags. The cost was 20 paise per bag.

4. Labour required/ha was estimated at the rate of one woman labourer for bagging 500 fruits and the wages @ Rs.30/- per day.

Table 10. Effect of varying periods of protection of fruits from the time of fruit set on the extent of damage caused by C. cucurbitae

treatments	percent-age of infested fruits	length/fruit at harvest (cm)	girth/fruit at harvest (cm)	weight/fruit at harvest (g)
fruits protected up to:				
3 days	86.0	13.73	8.43	45.33
5 days	93.0	15.10	9.27	48.00
7 days	6.7	22.17	11.23	100.00
9 days	nil	21.20	10.57	86.66
11 days	nil	21.33	11.30	93.33
13 days	nil	23.07	11.37	102.00
control	100.0	17.53	7.87	48.00
C.D.		2.76	1.35	23.95

Note: for assessment of size and weight, fruits infested by D. cucurbitae were selected from different treatments.

after setting had very severe damage (95%) and when protected up to 7 days damage was reduced to 6.7 per cent. When exposed on 9th day after fruit set there was no incidence of damage. Thus the result indicates that the flies do not lay eggs in fruits after 9th day of fruit set. The data also reveal the effect of bagging on the size and weight of the fruits. The variations caused by this practice were statistically significant. The length, girth and weight of the fruits protected for 7, 9, 11 and 13 days after fruit set came on par and significantly higher than the remaining treatments of protection for 3 and 5 days and control.

4.9. Evaluation of different methods for the control of *D. cucurbitae*

The data relating to the experiment and the results of statistical analysis of the same are presented in Table 11. The results showed that trapping the flies increased the mean number of fruit yield significantly over control, the numbers in the two treatments being 19.08 and 11.48 respectively. Yield from plots in which trapping was done regularly came on par with yield in plot treated with malathion spray (23.4). Plots in which fruits were bagged along with regular trapping of adults gave the maximum yield of 42.32. This treatment was followed by the practice of bagging the fruits without trapping of flies (35.32). Mean number of damaged fruits in

Table 11. Evaluation of different methods for the control of D. cucurbitae in field

treatments	number of fruits collected at different intervals after planting (weeks) / 4 m^2					mean	mean infested fruits
	8	9	10	11	12		
trapping flies	7.40	16.20	30.20	28.00	13.60	19.08	7.28
bagging fruits	16.60	33.00	55.20	43.40	28.40	35.32	0.00
bagging + trapping	17.60	38.80	65.40	53.40	36.40	42.32	0.00
malathion spray	8.80	14.60	40.20	32.40	21.40	23.40	6.80
control	5.60	9.80	16.40	14.20	11.40	11.48	6.40

C.D. for comparing means = 8.51
C.D. for comparing treatments = 3.77

treatments	weight of fruits collected at different intervals after planting (weeks) / 4 m^2					mean	mean infested fruits
	8	9	10	11	12		
trapping flies	616	1280	2588	2272	840	1519.20	254.4
bagging fruits	1056	2600	3713	3464	1972	2561.04	0.0
bagging + trapping	1460	3124	5236	4388	3024	3446.40	0.0
malathion spray	716	1224	3332	2640	1420	1866.40	297.6
control	428	748	1300	1112	704	858.40	265.6

C.D. for comparing means = 666.38
C.D. for comparing treatments = 378.55

control, in plots where flies were trapped and in plots sprayed with malathion came on par (6.4, 6.8 and 7.28 respectively). The relative efficacy of the treatments showed the same trend in the five weekly harvests commencing from the 8th week after planting.

The mean yield in weight also showed the same result. The highest yield (3446.40 g/4 m^2) was obtained from plots in which fruits were bagged along with trapping of adults. It was followed by the treatment in which bagging alone was done (2561.04 g/4 m^2). The difference between the two treatments was statistically significant. The yield obtained from plots in which flies were trapped and those in which five rounds of malathion spray was given came on par (1519.20 and 1866.40 g/4 m^2). Yield from control plot was significantly lower and was as low as 858.4 g/4 m^2. The relative ranking in the treatments (on weight basis) in five weekly observations were broadly in agreement.

The cost benefit of different treatment of the experiments was worked out in detail and presented in Table 12. The practice of bagging the fruits combined with trapping of adults gave the highest return of Rs.12196/ha and this treatment was followed by bagging of fruits alone from which an additional net return of Rs.11033/- would be obtained. The net additional

Table 12. Cost-benefit in adopting different methods of control against D. cucurbitae

treatments	total yield of good fruits		total additional income over control	total additional income (Rs.)	cost		net addi tion inco (Rs.
	wt. kg/ha	no./ha			cost (Rs.)	labour (Rs.)	
trapping	4750	62500	2069	6207	312	360	553
mechanical protection	9518	109375	6837	20511	2916	6562	1103
mechanical protection + trapping	10762	131250	8081	24243	3812	8235	1219
chemical control	5822	71875	3141	9423	800	1400	722
control	2681	34375	--	--	--	--	-

1. No. of polythene bags required/ha was calculated on the basis that the bags could be reused in alternate weeks during the harvest period and the bags would last for three seasons. The cost per bag was 20 paise. Removal of the bag could be done along with the harvest without incurring extra expenditure

2. Labour required/ha was worked out at the rate of one woman labourer for bagging 500 fruits and the wages @ Rs.30/- per day

3. Cost of malathion required/ha was Rs. 800/- per litre.

4. Labour required/ha for each spraying was 8 men labourers.

income from plots treated with malathion and those protected by trapping came very close with each other (Rs.7223/- and Rs.5535/- respectively).

4.10. Evaluation of number of flies trapped in different treatments

The data relating to the observation and the results of the same are presented in Table 13. The mean number of flies trapped in the plots in which fruits were bagged along with trapping of flies and in plots in which trapping of adults alone was done did not show significant variation. The mean total number of flies trapped during the first, second, third, fourth, fifth and sixth days after setting of the traps at weekly intervals commencing from flowering was 38.7, 53.59, 75.2, 74.03, 60.89 and 24 respectively.

Table 13. D. cucurbitae flies trapped in different treatments of field experiment

treatments	mean number of flies trapped (per plot) at different intervals after setting up the trap (days)						mean
	1	2	3	4	5	6	
			(8 weeks after planting)				
mechanical protection + trapping	4.43	5.86	9.30	8.49	8.06	2.31	6.18
trapping of adults alone	7.01	7.64	8.30	6.29	8.30	1.28	6.18
			(9 weeks after planting)				
mechanical protection + trapping	3.88	4.20	6.56	10.83	8.92	2.53	5.86
trapping of adults alone	5.20	4.76	8.12	9.50	8.12	8.28	6.08
			(10 weeks after planting)				
mechanical protection + trapping	2.88	7.30	9.69	10.70	9.24	1.76	6.13
trapping of adults alone	3.88	6.56	9.11	7.53	5.76	3.04	5.81
			(11 weeks after planting)				
mechanical protection + trapping	3.62	4.76	5.60	3.80	2.57	0.93	3.41
trapping of adults alone	1.92	4.56	2.50	3.37	1.92	0.72	2.39
			(12 weeks after planting)				
mechanical protection + trapping	3.12	5.45	8.55	7.07	3.71	1.19	4.57
trapping of adults alone	2.76	2.50	7.47	6.45	4.29	1.96	4.06

Note: The data were transformed using $\sqrt{x + 1}$ and subjected to statistical analysis. Significant variations were lacking in the data.

Discussion

5. DISCUSSION

Fruit flies are group of pests hard to control since the destructive larval stages of these insects are internal feeders in fruits and remain inaccessible to the common insecticide applications. Since the harvest is spread over a long period the application of insecticides for fruit fly control is bound to cause serious residue hazards especially when systemics like carbofuran, capable of killing the larvae inside the fruits, are used. Obviously non-insecticidal methods have to be resorted to for minimising the potential damage from the pest. Large scale trapping of adults prior to the egg laying in fruits or the mechanical exclusion of the insects from the fruits by bagging are potential methods of control. Techniques for standardising these method for the control of *D. cucurbitae* were tried in the present investigation.

In the first series of experiments twelve materials known as attractants of fruit flies were screened against *D. cucurbitae* adopting a simple method in the laboratory. The results presented in para 4.1 showed that eugenol, eucalyptus oil, citronella oil, borax and ammonium phosphate were totally ineffective against *D. cucurbitae*. Eugenol had been reported to be effective for trapping *D. dorsalis*

(Lakshmanan *et al.*, 1973; Shah and Patel, 1976; Fletcher et al., 1975; Tan, 1984). Ibrahim and Hashim (1980) had observed that methyl eugenol was less attractive to *D. cucurbitae* than to *D. dorsalis*. Citronella oil was reported to attract *D. dorsalis* and *D. zonatus* (Narayanan and Batra, 1960). But for *D. cucurbitae* it was reported to be less attractive (Lall and Singh, 1969).

Nakagawa (1975) observed that borax could attract *D. cucurbitae* and *D. dorsalis*. Economopoulos and Papadopoulos (1983) found that aqueous solutions of borax showed attractiveness to *D. oleae*.

Ammonia and ammonium salts showed attractiveness to *D. tryoni* (Bateman and Morton, 1981). Narayanan and Batra (1960) reported positive results with liquid ammonia for trapping *D. dorsalis*. *D. oleae* also showed positive response to ammonium salts (Longo and Benfatto, 1981). Eucalyptus oil, jaggery, honey, toddy and bittergourd fruits have not been evaluated as attractants of fruit flies so far. Thus the results obtained from the screening had an overall agreement with the earlier reports.

Among the remaining six materials tested the ripe bittergourd fruit was most effective in attracting the flies up to 12 hours after exposure. It was closely followed by honey, jaggery and sugar in a descending order of efficacy. But from 24th hour after exposure ripe bittergourd fruits became less effective than sugar, honey and jaggery. Toddy had limited attraction and the effect of vinegar lasted only for a very short period. In an overall assessment honey could be ranked as the best material for attracting the adults of D. cucurbitae followed by jaggery and sugar.

Since the association between the doses and the attractiveness of honey, sugar and jaggery was positive and linear, the optimum doses of the materials required for trapping the insect could not be fixed from the experiment. But the highest concentration of one per cent gave significantly higher catch and the effect remained unabated for four days from the time of exposure.

Immature bittergourd fruits did not attract the flies significantly. The results showed that the flies were predominently attracted by the feeding stimulus and for this purpose the immature fruits were not useful. The bittergourd fruits were screened for their attractiveness with a view to exploring the possibilities of maintaining the first series of fruits setting on crop, coated with some insecticides so as to attract and kill the flies available in the field. The poor attraction of flies by immature fruits and the inferiority of mature fruits to honey, jaggery and sugar during the later period of observation indicated the inferiority of the technique for the control of D. cucurbitae.

The results of the field experiment described in para 4.2 also showed that one per cent solution of honey was the best among the materials screened in the laboratory for attracting the flies and it was significantly superior to all other materials. Honey was followed by sugar and ripe bitter-gourd fruits. Toddy and vinegar which performed poorly in the laboratory screening showed better attractiveness under field conditions and the former came second to honey and on par with sugar. Probably the pungency of toddy and vinegar would have rendered the materials attractive under the open situation of the field while in the confined space of the laboratory it would have had some repellency. From the laboratory and field experiments one per cent honey could thus be chosen as the best attractant for trapping the adults of D. cucurbitae.

Plantain is being used as a bait material for trapping D. cucurbitae in some parts of the state. Different varieties of plantains were hence evaluated in field taking honey as the standard. The results presented in para 4.3 showed that palayankodan was the best variety of plantain for trapping the flies and it was closely followed by the variety 'poovan'.

These were on par with the standard used viz. honey. 'Nendran' and 'rasakadali' varieties were less preferred by the flies. The pulp of the former two varieties is comparatively softer than that of the latter varieties and that may be attributed as the factor for the greater attractiveness of the material. The results further showed that the cutting of the fruits crosswise or lengthwise did not significantly and consistently influence the efficacy of the bait. Evaluation of the plantain fruits as a bait material for trapping D. cucurbitae was done for the first time. Palayankodan is a cheap variety of fruit easily available throughout the State and throughout the year and hence may be chosen as the best bait material for trapping the adults of D. cucurbitae. The attractiveness of the material persisted effectively for a week and hence was found suitable for the mass trapping of the flies.

The utilisation of plant resistance is the best possible method for solving the problem of fruit borers without the risk of insecticide residue hazards. With this end in view the accessions of bittergourd maintained by the National Bureau of Plant Genetic Resources, Trichur, were screened for resistance to fruit flies and the accessions were grouped into different categories based on the level of resistance. The results presented in para 4.4 revealed that none of the available accessions was immune to the pest. The accessions

17B and 6 with 6.96 and 10.03 per cent of fruit infestation were identified as resistant ones. These were followed by the moderately resistant accessions 139, 83, 145, 35, 125 and 19 and they were significantly superior to check Priya.

As seen from the results presented in para 4.5 the comparative performance of the above resistant accessions and five of the moderately resistant accessions, when evaluated along with four other hybrids and two local cultivars, in the field, was not consistent. The accessions 17B and 6 found resistant in the initial screening became moderately resistant in the replicated field experiment. Accession 35 which was in the moderately resistant group in the initial screening came in resistant group in the replicated trial. The accessions 239 and 244 included in the replicated trial were found more resistant than accession 35. In general accessions 244, 239 and 35 ranked higher than other accessions in their relative resistance among the varieties included in the evaluation. This relative superiority is generally manifested in all the harvests commencing from the eighth week after planting. In spite of the higher resistance the yield of good fruits obtained from accession 244 was much lower than that of the check variety 'Priya' though in number of fruits the two accessions were on par. The yield of good fruits obtained from accessions 239 and 35 (1471 and 1349 g/plot respectively) was close to the yield obtained from Priya (1776 g). Thus in terms of the yield of good fruits the resistant varieties did not excel the susceptible check Priya. On this criterion the accession 17B which gave an yield of 2088 g/plot was the best. Since the ultimate objective is the net yield of undamaged fruits from the crop the accessions found more resistant in terms of the percentage number of infested fruits or in terms of the percentage weight of the infested fruits could not be recommended for replacing the recommended variety Priya. However, these accessions can be advantageously exploited in breeding programme for evolving resistant and high yielding varieties.

As observed from the data (Table 7) the relatively resistant accessions 239, 244 and 35 did not show any antibiosis towards D. cucurbitae when compared with the check variety Priya in terms of number of larvae, pupae and adults emerging or in terms of the larval and pupal mortality. On these criteria accession 17B alone was significantly superior to the susceptible check. Though accession 17B came on par with Priya in terms of the percentage of fruits infested on number basis, on weight basis it was significantly superior to check. Obviously the variety can be exploited advantageously through further breeding.

Darshan Singh *et al.* (1976) screened fourteen accessions of bittergourd and observed that BG 12 was less susceptible to *D. cucurbitae*. But this accession had 29.4 per cent fruit damage while the damage in the remaining accessions ranged from 32.83 per cent to 41.93 per cent. Lall and Singh (1969) had observed that the short green varieties of bittergourd were more resistant to *D. cucurbitae*. This was not in agreement with the present observations. Padmanabhan (1989) screened 66 accessions of bittergourd in two field trials and grouped them into moderately resistant, moderately susceptible and highly susceptible ones. Only eight accessions were identified as moderately resistant ones and in those accessions the percentage of fruits damaged ranged from 10 to 20. Obviously the levels of resistance so far observed in bittergourd accessions/varieties appear to be inadequate for recommending any one of them for cultivation without the risk of significant levels of damage if left without insecticidal protection. In the present investigation also none of the accessions screened showed consistently low levels of infestation for facilitating the recommendation for replacing the high yielding susceptible varieties now being extensively cultivated (Priya). It may be necessary to intensify further breeding programme to incorporate the resistant genes in high yielding accessions to exploit resistance as an effective method for minimising the fruit fly damage.

Cloth bags were found to give effective protection to bittergourd fruits from the attack of D. cucurbitae (Cleghorn, 1914). Paper bag was reported to give adequate protection from the flies (Hutson, 1940; Miller, 1940; Misaka et al., 1940). Batra (1960) used paper and cloth bags against D. dorsalis and observed that the former warded off the attack better and the latter was effective when the bags covered the fruits loosely. However they observed that the using of the bags in large plantations was not economical. The paper bags got torn in heavy rains and when wet the cloth bags stick to the surface of the fruits, thus facilitating the egg laying of the insect through the cloth. The results of the experiment detailed in para 4.7 also showed that paper and cloth bags gave protection reducing the damage to the level of 26.67 and 40 per cent respectively as against 73.33 per cent damage in control. But the polythene bag included in the experiment gave 100 per cent protection to the fruits.

Though secondary rotting of bagged fruits was reported earlier due to bagging (Misaka et al., 1940) the data obtained from the present experiment revealed that the fruits enclosed in paper and polythene bags had better size and weight than in the case of the fruits kept closed with cloth bag or those left uncovered. Even when the entry of light was prevented to the fruits enclosed in paper and cloth bags the growth of the fruit was not adversely affected. Favourable influence of paper and polythene bags on the size of the fruits was identical and it showed that sunlight was not exerting any influence on the growth and maturation of the fruits in spite of the chlorophyll content of the rind. The increase in the yield of unattacked bittergourd fruits obtained by the use of the three types of bags revealed that the polythene bags would give the highest returns. The results of the experiment has conclusively shown that protecting fruits from the time of setting till harvest with polythene bag was a safe, fool-proof and economical technology for preventing fruit fly damage in bittergourd.

It has been observed that the older fruits are not generally preferred by the flies for egg laying. With a view to ascertaining the stages at which the fruits remained susceptible to the egg laying of D. cucurbitae a field experiment was conducted. The results of the experiment (para 4.8) showed that the fruits protected for nine days after setting were completely free from insect injury while those protected for seven days had a low damage of 6.7 per cent. This revealed that fruits need protection for a period of 7 to 9 days only from the time of fruit set. A precise assessment of the susceptible stage of the fruits to the attack of D. *cucurbitae* was being attempted for the first time.

In the last field experiment the different methods for the control of fruit flies were compared and the results (para 4.9) showed that the continuous trapping of the flies commencing from the time of first flowering significantly reduced the damage caused by D. *cucurbitae* and the treatment came on par with the treatment given five rounds of insecticide spraying. Though the enclosing of fruits with polythene bags gave 100 per cent protection in an earlier experiment the plots in which the bagging and trapping of fruit flies were done gave significantly higher yield than in plots in which the bagging alone was done. The flies available in the plots might have damaged some female flowers even prior to fertilization and bagging and that might have affected the total yield from the plot. The cost benefit data (para 4.9) showed that the practice of bagging the fruits along with the trapping of the flies was most advantageous and it was closely followed by the bagging of the fruits alone. The results conclusively showed that the bagging of the fruits was not uneconomical as observed by Batra (1960) even when practiced commercially engaging labourers as detailed in Table 12. The trapping of flies using plantain fruits as an attractant and carbofuran granule as a poison was also shown to be a technology as effective as spraying the crop five times from the commencement of flowering. The former technique is ecologically sound and least hazardous to man since the used up baits could be collected and safely disposed off avoiding environmental pollution.

The results presented in para 4.10 showed that the population of flies, as indicated by the catch in traps, did not vary significantly in different treatments or among the different observations during the period of the experiment. In spite of that damage of fruits in plots where the trapping of the flies was done came significantly lower than the damage in plots without trapping of flies. Lack of significant variations among the population in different treatments might be due to the fact that the plots were small (4 m^2) and the flies which are swift fliers might have moved from plot to plot in the experimental area. The flies on reaching the plots would have got attracted to the baits and got killed prior to the egg laying in fruits whereas all the flies reaching the plots in which baiting was not done laid eggs and caused damage. The results indicated that the efficacy of baiting might be high when the technique is adopted over extensive areas in the field. If the practice is followed in all crops susceptible to the pest prevalent in a location over a long period of time the population of the insect can be brought below the economic threshold level and maintained at the level without the direct use of any pesticide. Without insecticide use it is impossible to produce marketable fruits from bittergourd and being a lucrative vegetable farmers often use highly toxic pesticides like carbofuran, even during the flowering and fruiting stages of the crop. The yield obtained from the crop often contain pesticide residues above tolerance limit. This menace can be minimised or even eliminated if the practices of bagging the fruits at flower set and the baiting of flies from the time of flowering till the last harvest of fruits, are popularised among the farmers.

Summary

SUMMARY

Bittergourd is very popular among the vegetable growers in Kerala. Fruit flies take a heavy toll of this crop and intense use of pesticides is a common practice of cultivators often leading to serious residue hazards in the marketed fruits. In the present investigations an attempt was made to standardise non-insecticidal methods of control for tackling this pest problem.

1. Laboratory evaluation of different materials as attractants for baiting the adults of *D. cucurbitae*

Potential attractants of fruit flies viz. eugenol, eucalyptus oil, citronella oil, borax, ammonium phosphate, vanilla essence, jaggery, sugar, vinegar, honey, toddy and bittergourd fruits were screened against the adults of *D. cucurbitae*. Cotton swabs dipped in solutions of the attractants (at widely spaced concentrations) were taken in watch glasses and exposed to preconditioned flies in insect proof wooden cages. Eugenol, eucalyptus oil, citronella oil, borax, ammonium phosphate and vanilla essence did not show any attractiveness to the flies.

Based on the preliminary screening six materials which showed attractiveness to the flies were chosen for further

experiments. Three graded concentrations of honey, sugar, jaggery, toddy and vinegar were tested for their attractiveness to the flies in the laboratory at intervals of 10 minutes up to 90 minutes and then at 6, 12, 24, 48 and 72 h. after exposure. The results showed that (1) honey at the highest concentration-1% attracted the maximum number of flies, (2) honey at a middle concentration of 0.25% also came on par with the higher concentration of jaggery and sugar indicating that honey was the best of the three treatments, (3) toddy was not effective for attracting D. cucurbitae , (4) immature stages of bittergourd (2, 4 and 6 days old) had poor attraction showing that egg laying stimulus had no influence in the behaviour of flies and (5) ripe bittergourd fruits showed maximum attraction to the flies up to 12 hours of exposure and in subsequent observations sugar, honey and jaggery ranked higher than bittergourd fruits, thus showing that persistence was more for sugar, honey and jaggery.

2. Field evaluation of the attractants

A field experiment in randomised block design conducted at the Instructional Farm, College of Agriculture, Vellayani, also showed that one per cent honey was significantly superior to all other treatments. It was followed by sugar and ripe bittergourd fruits. Ripe bittergourd fruits which showed the highest attractiveness in the laboratory was found inferior in field evaluation. Toddy had a better performance in the field than in the laboratory. Vinegar which failed to show significant attractiveness to the flies in the laboratory was found effective as a bait in field evaluation.

3. Evaluation of different banana varieties as attractants for baiting *D. cucurbitae*

The evaluation was done in field using four varieties of banana (nendran, poovan, palayankodan and rasakadali), taking honey as standard. Honey one per cent, palayankodan and poovan varieties of banana fruits came on par. Lengthwise and crosswise cutting of fruits did not show consistent influence on the attractiveness of the materials. The effect of the materials persisted effectively for a week, thus showing that a weekly changing of the bait would be sufficient under field situation.

4. Relative susceptibility of different varieties/accessions of bittergourd

Forty seven accessions of bittergourd grown at NBPGR, Vellanikkara were screened and the result showed that none of the accessions was highly resistant to the flies. Two accessions 6 and 17B came in the resistant group, 26 accessions including the check Priya came under the moderately resistant group, twelve came under the susceptible group and the remaining six accessions were found highly susceptible.

Seven accessions/varieties selected in the preliminary screening, four new accessions supplied by NBPGR, two local varieties along with a susceptible check Priya were evaluated for their resistance to fruit flies in a field experiment at the Instructional Farm, Vellayani. Accessions 17B and 6 found resistant in the initial screening became moderately resistant in the replicated field experiment. Accession 35 which was in the moderately resistant group in the initial screening came in resistant group in the replicated trial. The accessions 239 and 244 which were not included in the initial screening were found more resistant than accession 35. Based on initial screening and ranking based on number and weight of infested fruits, accessions 244, 239 and 35 were found superior to other accessions in the relative resistance among the varieties included in the evaluation. In terms of yield of good fruits the resistant varieties 244, 239 and 35 were inferior to the susceptible check Priya. Hence the varieties are not suitable for replacing the popular variety Priya in the field though they can be advantageously exploited in breeding programmes for evolving resistant and high yielding varieties.

Laboratory observation on the infested fruits collected from different varieties (250 g samples) revealed that the relatively resistant NBPGR accessions 239, 244 and 35 did not show any antibiosis towards D. cucurbitae, when compared with the check variety Priya. Accession 17B had significantly lower number of maggots, pupae and adults and the larval and pupal mortalities were significantly higher in that accession. But the resistance shown by the variety was not consistent. This variety also can hence be used in the breeding, desirable accessions.

5. Evaluation of different materials for caging **developing bittergourd fruits for the control of fruit fly damage.**

Paper bags and cloth bags did not completely protect the fruits from the egg laying by the flies though there was significant reduction when compared to control. The fruits covered with polythene bags gave complete protection of the fruits from egg laying and subsequent damage by the emerging maggots.

The cost benefit of the mechanical protection using different types of bags revealed that polythene bags gave the highest return (Rs. 13697/ha) while net additional income obtained by suing paper bag was Rs. 7235/ha only. Cloth bags by virtue of their high cost, were not found economical.

An observational trial revealed that the bagging of developing fruits had a favourable influence on size and weight of the fruits when full grown and the cutting of sunlight by using paper bags had no adverse effect on the fruits. The effect of covering the fruits with the polythene bags for varying periods from fruit set, was studied in a field experiment and it was found that fruits protected up to eight days were completely free from the attack by the flies. The fly did not lay eggs on fruits beyond eighth day after setting.

6. Comparative evaluation of non-insecticidal methods for the control of *D. cucurbitae* on bittergourd

The effect of bagging the developing fruits, trapping the fruit flies and combination of both in comparison with the current practice of spraying the crop at weekly intervals after fruit set was studied through a field experiment at the Instructional Farm, Vellayani. The best yield was obtained from plots in which the fruits were bagged and trapping of adults were done. It was followed by bagging alone. The trapping of flies came on par with insecticidal spraying and significantly superior to control.

References

REFERENCES

*Ajjan, I. (1968). Efficiency of the plastic steiner trap as compared to the glass bell-shaped trap for fruit flies catching. Proc. N. cent. Brch. Am. Ass. econ. Ent. 23(1): 51-52.

Alexander, B.H., Beroza, M., Oda, T.A., Steiner, L.F., Miyashita, D.H. and Mitchell, W.C. (1962). The development of male melon fly attractants. J. Agric. Food Chem. 10: 270-276.

Altamirano, D.M. and Macabasco, C.B. (1960). A study of the biology and control of the ampalaya fruit fly. Philipp. J. Agric. 25(1-4): 101-125.

Al-zaghal, K. and Mustafa, T. (1987). Studies on the population of the olive fruit fly Dacus oleae Gmel. (Diptera : Trypetidae) in Jordan. J. Appl, Entomol. 103(5): 452-456.

Anand, S.K. and Ramchandani, N.P. (1984). Fumigation of Alphanso mangoes with ethylene dibromide. Plant Prot. Bull. India 36(2/3): 131-132.

Armstrong, J.W. (1982). Development of a hot water immersion quarantine treatment for Hawaiian-grown Brazilian bananas. J. Econ. Entomol. 75(5): 787-790.

Armstrong, J.W. and Garcia, D.L. (1985). Methyl bromide quarantine fumigation for Hawaii grown cucumbers infested with melon fly and oriental fruit fly (Diptera : Trypetidae). J. Econ. Entomol. 78(6): 1308-1310.

Awadallah, A. and Nadim, A.L. (1970). The chemical control of the olive fruit fly, Dacus oleae Gmel. in Kom-Oshim district (Fayoum Governorate) during 1963 and 1964 seasons (Diptera : Trypetidae). Bull. Entomol. Soc. Egypt. Economic Series 4: 135-141.

Azab, A.K., El-Nahal, A.K.M. and Swailem, S.M. (1964). The relative toxicity of some common insecticides to the adults of the pumpkin fly Dacus ciliatus Loew. (Diptera : Trypetidae). Bull. Soc. Egypte. 47: 39-50.

Ba-Angood, S.A.S. (1977). Control of the melon fruit fly Dacus frontalis Becker (Diptera : Trypetidae) on cucurbits. J. Hort. Sci. 52(4): 545-547.

Back, E.A. and Pemberton, C.C. (1914). Life history of melon fly. J. Agric. Res. 3: 269-274.

Bagnoli, B., Ballatori, E., Belcari, A., Niccoli, A., Pucci, C., Quaglia, F. and Ricci, C. (1983). Analysis of catches of adults of Dacus oleae Gmel. effected with chromotropic traps. Redia 66: 645-660.

Balasubramaniam, G., Abraham, E.V., Vijayaraghavan, S., Subramoniam, T.G., Santhanaraman, T. and Gunasekharan, C.R. (1972). Use of male annihilation technique in the control of the oriental fruit fly, Dacus dorsalis Hendel. Indian J. Agric. Sci. 42(11): 975-977.

Bateman, M.A. and Morton, T.C. (1981). The importance of ammonia in proteinaceous attractant for fruit flies (Fam: Trypetidae). Aust. J. Agric. Res. 32(6): 883-903.

Bateman, M.A., Insunza, V. and Arretz, P. (1973). The eradication of Queensland fruit fly from Easter Land. Plant Prot. Bull. FAO 21(5): 114.

Batra, H.N. (1954). Biology and control of other fruit flies in India. Indian J. Agric. Sci. 23:87-112.

Batra, H.N. (1964). Valve of clensel as a chemical attractant and preliminary studies on population fluctuations and movement of fruit flies in the orchard. Indian J. Agric. Sci. 34(1): 28-37.

Bhatt, A.A. and Bhalla, O.P. (1978). Relative toxicity of some insecticides to the adults of melon fly, Dacus cucurbitae Coq. J. Entomol. Res. 2(1): 114-116.

Blatter, E., Cains, J.F. and Mhaskar, K.S. (1935). Indian medicinal plants. Second edition. M/s. Bishen Singh, Mahendrapal Singh, New Connaught Place, Dehra Dun, 1130-1132.

Broumas, T. (1985). Application trials of trapping systems for control of Dacus oleae. Ann. Inst. Phytopathol. Benaki 14(2): 157-166.

Broumas, T., Katsoyannos, P., Yamvrias, C., Strong, F., Liaropoulos, C. and Haniotakis, G. (1983). Control of the olive fruit fly in a pest management trial in olive culture. In Fruit Flies of Economic Importance. Proceedings of the CEC|IOBC International Symposium, Athens, Greece, 16-19 November 1982 (edited by Cavalloro, R.), Rotterdam, Netherlands, A.A.Balkema, 584-592.

Bugiani, A., Cinquanta, A. and Ferrati, U. (1971). Trials on the control of olive fly. Frutticottura 33(6): 23-29.

Bunting, B. and Milsum, J.N. (1930). The culture of vegetables in Malaya. Bull. Dept. Agric. S.S. & FMS Gen. Ser. (1): 78.

Cavalloro, R. and Delrio, G. (1973). Radio sterilization of Dacus oleae Gmelin and prospects of control by means of the sterile-male technique. Redia 54: 153-167.

Chang, S.L. and Peng, C.C. (1971). An investigation of the insecticidal test for melon fly Dacus caudatus F. (Trypetidae, Diptera). Plant Prot. Bull. Taiwan 13(3): 101-109.

Chen, K.H. (1960). Studies on the melon fly control. Agric. Res. 9: 43-51.

Clausen, C.P. (1956). Biological control of fruit flies. J. Econ. Entomol. 49(2): 176-178.

Cleghorn, J. (1914). Melon culture in Peshin, Baluchistan and some account of the melon fly pest. Agric. J. India 124-140.

Couey, H.M. and Hayes, C.F. (1986). Quarantine procedure for Hawaiian pappaya using fruit selection and a two stage hot water immersion. J. Econ. Entomol. 79(5): 1307-1314.

Cunningham, R.T., Chambers, D.L., Steiner, L.F. and Ohinata, K. (1975). Thixcin - thickened sprays of cuelure + naled : Investigation of rates of application for use in male annihilation of melon fly. J. Econ. Entomol. 68(6): 857-860.

Cunningham, R.T. and Steiner, L.F. (1972). Field trials of cuelure + naled on saturated fibre board blocks for control of the melon fly by the annihilation technique. J. Econ. Entomol. 65(2): 505-507.

Cunningham, R.T., Steiner, L.F. and Ohinata, K. (1972). Field tests of thickened sprays of methyl eugenol potentially useful in male annihilation programme against oriental fruit flies. J. Econ. Entomol. 65(2): 556-559.

Dale, D., Das, N.M. and Nair, M.R.G.K. (1966). Studies on the residual effects of some insecticides in soil to maggots of the melon fly D. cucurbitae Coquillett. Agric. Res. J. Kerala 4(2): 85-88.

Dale, D. and Nair, M.R.G.K. (1966). Studies on the relative toxicity of some insecticides to adults of Dacus cucurbitae (Coquillett) when used in bait sprays. Agric. Res. J. Kerala 4(1): 74-77.

Damiano, A. (1967). Evaluation of new organo phosphorus compounds against olive fruit fly in Tripolitania. Int. Pest Control 9(3): 13-17.

Darshan Singh, Ramzan, M. and Gill, S.P.S. (1976). Field incidence of cucurbit fruit fly Dacus cucurbitae Coq. on different cultivars of bittergourd at Ludhiana. Indian J. Plant Prot. 15(1): 145-146.

Das, N.M., Remamony, K.S. and Nair, M.R.G.K. (1968). On control of melon fly Dacus cucurbitae (Coq.) with some newer synthetic insecticides applied as cover sprays. Agric. Res. J. Kerala 6(1): 43-45.

Doolittle, R.E., Keiser, I. and Miyashita, D.H. (1970). Comparative attractiveness to the melon fly of mixture of cuelure and 4-(P-hydroxy phenyl)-2-butanone. J. Econ. Entomol. 63(1): 339-340.

Economopoulos, A.P. (1977). Controlling D. oleae by fluorescent yellow traps. Entomol. Exp. Appl. 22(2): 183-190.

Economopoulos, A.P. (1978). Prospects for the control of Dacus oleae (Gmelin) (Diptera, Tephritidae) by methods that do not involve insecticides, the sterile insect release technique and olfactory and visual traps, integrated approach. International organisation for biological control of noxious animals and plants, West Palearctic regional section. Joint meeting of the working groups : Biological control of olive pests; Genetic control of Rhagoletin cerasi, Genetic control of ceratitis capitata; Genetic control methods against pests. Sessari (Sardinia, Italy) 15-20, May 1978, 42-49.

Economopoulos, A.P. (1979). Attraction of Dacus oleae (Gmelin) (Diptera, Tephritidae) to dour and colour traps. Z. Angicio. Entomol. 88(1): 90-97.

Economopoulos, A.P. and Papadopoulos, A. (1983). Wild olive fruit flies caught on Sticky traps with odour, colour and combination of the two attractants. Redia. 66: 409-416.

Economopoulos, A.P. and Stairopoulou-Delivoria, A. (1984). Yellow sticky rectangle with ammonium acetate slow-release dispenses : an efficient long lasting trap for Dacus oleae. Entomol. Hellenica 2(1): 17-23.

El-Tahir, E.T. and Venkataraman, T.V. (1970). Responses of fruit flies (Tephritidae) to synthetic chemical attractants in Sudan. Sudan Agric. J. 5(1): 60-62.

Eta, C.R. (1986). Review - eradication of the melon fly from Shortland Islands, Western Province, Solaman Islands. In Solaman Islands Agriculture Quarantine Service, 1985 annual report, 14-23.

Fenili, G.A. and Zocchi, R. (1967). Control experiments against D. oleae in coastal Tuscany during 1965. Redia. 50(2): 69-74.

Fernando, M. and Udurawana, S.B. (1941). The relative resistance of some strains of bittergourd to the cucurbit fruit fly. Trop. Agriculturist 96(6): 347-352.

Fletcher, B.S., Bateman, M.A., Hart, N.K. and Lamberton, J.A. (1975). Identification of a fruit fly attractant in an Australian plant Zieia smithii as o-methyl eugenol. J. Econ. Entomol. 68(6): 815-816.

Fullaway, D.T. (1915). Report of the Entomologist. Rept. Hawaii Agric. Stat. 43-50.

Fytizas, E. and Mourikis, P.A. (1977). Susceptibility of different stages of D. oleae to Altosid. Z. Angew. Entomol. 84(1): 107-112.

Gopalan, C., Rama Sastri, B.V. and Balasubramoniam, S.C. (1982). Nutritive valve of Indian foods. Indian Council of Medical Research, Natural Institute of Nutrition, Hyderabad.

Gupta, J.N. and Verma, A.N. (1978). Effectiveness of some insecticidal dusts, applied to soil against the last stage maggots of melon fruit fly D. cucurbitae (Coquillett) (Diptera : Tephritidae). Haryana Agric. Univ. J. Res. 7(3): 133-135.

Haniotakis, G.E. (1981a). Potential practical use of the olive fruit fly sex attractant pheromones. In Proceedings International Symposium of IOBC/WPRS on integrated control in agriculture and forestry, Vienna, 8th-12th October 1979. 471-476.

Haniotakis, G.E. (1981b). Field evaluation of the natural female pheromone of D. oleae (Gmelin). Environ. Entomol. 10(6): 832-834.

Haniotakis, G.E., Kozyrakis, E. and Bonatsos, C. (1986). Control of the olive fruit fly, Dacus oleae Gmel. (Dept., Tephritidae) by mass trapping: pilot scale feasibility study. J. Appl. Entomol. 101(4): 343-352.

Hargreaves, J.G., Murray, D.A.H. and Cooper, L.P. (1986). Studies on the stinging of passion fruit by Queensland fruit fly, Dacus tryoni and its control by baits and cover sprays. Queensl. J. Agric. Anim. Sci. 43(1): 33-40.

Hill, A.R. (1986). Reduction in trap captures of female fruit flies (Diptera : Tepritidae) when synthetic male lures are added. J. Aust. Entomol. Soc. 25(3): 28-214.

Hopper, G.H.S. (1975). Sterilization of Dacus cucumis French (Diptera : Tephritidae) by gamma radiation. I. Effect of dose on fertility, survival and competitiveness. J. Aus. Entomol. Soc. 14(1): 81-87.

Hooper, G.H.S. (1978). Effects of combining methyl eugenol and one-lure on the capture of male tephritid fruit flies. J. Aust. Entomol. Soc. 17(2): 189-190.

Hooper, G.H.S. and Drew, R.A.I. (1978). Comparison of the efficiency of two traps for male tephritid fruit flies. J. Aust. Entomol. Soc. 17(1): 95-97.

Hutchin, A.E. and Sando, L. (1941). Gourds - use, cultivation, identification. Univ. Minn. Agric. Expt. Sta. Bull. 336-356.

*Hutson, J.C. (1940). Report on the work of the Entomological Division. Adm. Rep. Dir. Agric. Ceylon, 36-41.

Ibrahim, A.G. and Hashim, A.G. (1980). Efficacy of methyl eugenol a male attractant for Dacus dorsalis Hendel (Diptera : Tephritidae). Pertanika. 3(2): 108-112.

Iwahashi, O. (1977). Eradication of the melon fly, D. cucurbitae from Kume Island, Okinawa with the sterile insect release method. Res. Popul. Ecol. 19(1): 87-98.

Iwahashi, O., Ito, Y., Zukeyama, H. and Yogi, Y. (1976). A progress report on the sterile insect release of melon fly, D. cucurbitae Coquillett (Diptera : Tephritidae) on Kume Is., Okinawa. Appl. Entomol. Zool. 11(3): 182-193.

Jacobson, M., Keiser, I., Harris, E.J. and Miyashita, O.H. (1976). Impurities in one lure attractant to female Tephritidae. J. Agric. Food Chem. 24(4): 782-783.

Katsoyannos, B.J. (1983). Captures of Ceratitis capitata and D. oleae flies (Diptera : Tephritidae) by Mc Phail and Rebell colour traps suspended on citrus, fig and olive trees on Chios, Greece. In Fruit flies of economic importance. Proceedings of the CEC/IOBC, International Symposium, Athens, Greece, 16-19 November 1982. 451-456.

Kavadia, V.S., Gupta, H.C.L. and Pareek, B.L. (1978). Comparative efficacy and residues of insecticides applied singly or in mixtures with attractants against fruit fly affecting long melon (Cucumis utilissimus Duthie and Fuller). Indian J. Plant Prot. 5(2): 183-187.

Keiser, I., Kobayasi, R.M., Schneider, E.L. and Tamikawa, I. (1973). Laboratory assessment of 73 insecticides against the oriental fruit fly, melon fly and mediterranean fruit fly. J. Econ. Entomol. 66(4): 837-839.

Khandelwal, R.C. and Nath, P. (1979). Evaluation of cultivars of water melon for resistance to fruit fly. Egypt. J. Genet. Cytol. 8(1): 46-56.

Koidsumi, K. and Shibata, K. (1935). Notes on Antecology of some fruit flies. J. Soc. Trop. Agric. Formosa, 7(4): 370-378.

Koyama, J., Teruya, T. and Tanaka, K. (1984). Eradication of the oriental fruit fly (Diptera : Tephritidae) from the Okinawa Islands by a male annihilation method. J. Econ. Entomol. 77(2): 468-472.

Lakshmanan, P.L., Balasubramoniam, G. and Subramoniam, T.R. (1973). Effect of methyl eugenon in the control of the oriental fruit fly Dacus dorsalis Hendel on mango. Madras Agric. J. 60(7): 628-629.

Lall, B.S. and Singh, S.N. (1959). On the biology of the melon fly, D. cucurbitae (Coq). Sci. and Cult. 25: 159-161.

Lall, B.S. and Singh, S.N. (1960). A trap for the control of the melon fly Dacus cucurbitae Coq. Sci. and Cult. 25(9): 541-546.

Lall, B.S. and Singh, B.N. (1969). Studies on the biology and control of melon fly Dacus cucurbitae (Coq.) Diptera : Trypetidae. Labder J. Sci. Tech. India 7(2): 148-153.

Lee, L.W. and Chang, K.H. (1978). Integrated control of plant protection in citrus - integrated control of oriental fruit flies in Taiwan. In Proceedings International Symposium of IOBC/WPRS on integrated control in agriculture and forestry, Vienna, 8th to 12th October 1979. 568-571.

Longo, S. and Benfatto, D. (1981). Observations on catches of D. oleae Gmel. with bottle traps in relation to their position in the tree canopy. Inf. Fitopatol. 31(1/2): 45-50.

Maddison, P.A. (1983). Queensland fruit fly. Advisory leaflet, South Pacific Commission (18): 3.

Mazomenos, B.E. and Haniotakis, G.E. (1985). Male olive fruit fly attraction to synthetic sex pheromone components in laboratory and field tests. J. Chem. Ecol. 11(3): 397-405.

Mazomenos, B.E., Hariwtakis, G.E., Ioannon, A., Spanakis, I. and Kozirakis, B. (1983). Field evaluation of olive fruit fly pheromone traps with various dispenses and concentration. In Fruit flies of economic importance. Proceedings of the CEC/IOBC International Symposium, Athens, Greece, 16-19 November 1982 (edited by Cavalloro, R.) Rotterdam, Netherlands, A.A. Balkema. 506-512.

Melis, A. (1957a). Experiments on the control of Dacus Oleae in Italy in 1954. Redie 40: 67-139.

Melis, A. (1957b). The campaign against Dacus oleae on the coast of Tuscany in 1955. Redia 41: 29-74.

Miller, N.C.E. (1940). Fruit flies. Malay. Agric. J. 28(3): 112-121.

Misaka, K., Koreishi, T. and Sato, A. (1940). Observation concerning the injuries of fruit flies in fruits and vegetables in Formosa. Injuries to Mango. Japanese Res. Bull. Pl. Quar. Sta. (8): 31.

Monro, J. and Richardson, N.L. (1969). Traps, male lure, and a warning system for Queensland fruit fly Dacus tryoni (Frogg.) (Diptera, Trypetidae). Aust. J. Agric. Res. 20(2): 325-338.

Nadkarni, K.M. (1954). Indian Materia Medica, revised and enlarged by A.K. Nadkarni, Popular Book Depot, Bombay.

Nagappan, K., Kamalanathan, S., Santhanaraman, R. and Ayyasamy, M.K. (1971). Insecticidal trials for the control of the melon fly Dacus cucurbitae Coq. infesting snakegourd, Trichosanthes anguina. Madras Agric. J. 58(8): 688-690.

Nakagawa, S., Suda, D., Urago, T. and Harris, E.J. (1975). Gallon plastic tub : a substitute for the Mc Phail trap. J. Econ. Entomol. 68(3): 405-406.

Narayanan, E.S. (1953). Fruit fly pests of orchards and kitchen gardens. Ind. Farm 3(4): 29-31.

Narayanan, E.S. and Batra, H.N. (1960). Fruit flies and their control. ICAR Monograph : 68.

Nath Prem (1965). Cucurbitaceous vegetables in Northern India. Extn. Bull. No.7, Univ. Udaipur, India.

Nath, P. (1966). Varietal resistance of gourds to the fruit fly. Indian J. Hort. 23(1/2): 69-78.

Nath Prem, Dutta, O.P., Velayudhan, S. and Swamy, K.R.M. (1976). Inheritance of resistance to fruit fly in pumpkin. Sabro J. 8: 117-119.

Niccoli, A. (1975). Contribution to the knowledge of the action of pheromones and synthetic compounds on insects. I. Attractiveness of three alkenes to the adult of D. oleae Gmel. Redia 56: 91-107.

Nishide, T. (1963). Zoo geographical and ecological studies of Dacus cucurbitae in India. Tech. Bull. Hawaii Agric. Expt. Stat. 54: 28.

Nishida, T. and Bess, H.A. (1957). Studies on the ecology and control of D. cucurbitae Coq. Tech. Bull. Hawaii Agric. Expt. Stat. (34).

Orphanidis, P.S. (1978). Influence of olives immersed in solutions of a formulation of methoprene a chemical analogue of a juvenile hormone of insects on D. oleae (Gmel). Ann. Inst. Phytopathol. Benaki 11(3): 241-253.

Orphanidis, P.S. and Kapetanakis, E.G. (1979). Effects on the olive fly in spraying the olive trees with a formulation of methoprene, analogue of insect juvenile hormone. Ann. Inst. Phytopathol. Benaki 12(1): 81-85.

Orphanidis, P.S. and Kalmoukos, P.K. (1979). Insecticide mixtures as a means for improving protein hydrolysate baits used against the olive fly Dacus oleae. Z. Argen. Zool. 60(1): 75-86.

Orphanidis, P.S., Kalmonkos, P.E. and Betzios, B.C. (1969). Carbamate insecticides compared with OP insecticides in hydrolysed protein baits for the control of the olive fly D. oleae. Z. Argen. Entomol. 63(4): 389-405.

Orphanidis, P.S., Karayannis, G.B., Alexo Poulou, P.S., Tsakmakis, A.A. and Daniel Idon, R.K. (1958). Experiences concernare e' efficacite de certains insecticides phosphores, sur to Dacus oleae. Ann. Inst. Phytopath. 1: 229-289.

Padmanabhan, V. (1989). Host resistance in bittergourd Momordica charantia L. to the infestation by the fruit fly Dacus cucurbitae Coq. M.Sc. Thesis, College of Horticulture, Vellanikkara, Trichur.

Pareek, B.L. and Kavadia, V.S. (1988). Economic insecticidal control of two major pests of musk melon Cucumis melo, the pumpkin beetle Raphidopalpa sp. and the fruit fly Dacus cucurbitae in Rajasthan, India. Trop. Pest Manage. 34(1): 15-18.

Planes, S. and Del Rivero, J.M. (1966). Experiments carried out with cover sprays against the olive fly (D. oleae) in eastern Spain. Bol. Patol. Veg. Entomol. Agric. 29: 267-277.

Prokopy, R.J. and Economopoulos, A.P. (1975). Attraction of laboratory - cultured and wild D. oleae fles to sticky coated Mc Phail traps of different colours and odours. Environ. Entomol. 4(2): 187-192.

Pucci, C., Ballotori, E., Tirimbelli, D. and Ambrosi, G. (1983). Selecting the best date for olive harvest in years of high Dacus infestation. Frustula Entomol. 5: 3-30.

Ravindranath, K. and Sasidharan Pillai, K. (1986). Control of fruit fly of bittergourd using synthetic pyrethroids. Entomol 11(4): 269-272.

Ricci, C. and Ceccarelli, S. (1979). Observations on the captures of Dacus oleae Gmel. by means of coloured 'Prokoboll' traps in Umbria. Redia 62: 17-33.

Ricci, C., Pucci, C., Bagroli, B., Ballatori, E., Belcari, A., Niccoli, A. and Quaglia, F. (1983). Catches of females of D. oleae (Gmel) with chromotropic traps and infestation of olives. Redia 66: 661-682.

Rigney, C.J. and Wild, B.L. (1975). Dacus tryoni : ethylene dibromide treatment of orange. J. Econ. Entomol. 68(5): 653-654.

Russo, G. (1960). Eco-biological observation on Dacus oleae and control experiments in Salerao in 1959. Bull. Lab. Ent. agric. 18: 298-386.

Russo, L.F. (1968). Bio-ecological observation on D. oleae and chemical control test against it in Ascea Marina. Boll. Lab. Ent. Agc. Fillippa. Silvestri. 26: 63-98.

Saddik, S., Awadallah, A. and Fam, E. (1964). The effects of some new synthetic insecticides on the melon fruit fly D. ciliatus. Loew. Agric. Res. Rev. Cairo 42(3): 47-51.

Saddik, S. and Rizkallah, R. (1970). Effect of certain insecticides on the melon fruit fly, D. ciliatus. Loew Agric. Res. Rev. 48(1): 131-134.

Seo, S.T., Chambers, D.L., Akamine, E.K., Komura, M. and Lee, C.Y.L. (1972). Hot water ethylene dibromide fumigation-refrigeration treatment for mangoes infested by oriental and Mediterranean fruit flies. J. Econ. Entomol. 65(9): 1373-1374.

Seo, S.T., Hu, B.K., Komura, M., Lee, C.Y.L. and Harris, E.J. (1974). Dacus dorsalis : Vapour heat treatment in papayas. J. Econ. Entomol. 67(2): 240-242.

Seo, S.T., Kopayashi, R.M., Chambers, D.L., Steiner, L.F., Balock, J.W., Komura, M. and Lee, C.Y.L. (1971). Fumication with methyl bromide plus refrigeration to control infestation of fruit flies in agricultural commodities. J. Econ. Entomol. 64(5): 1270-1274.

Severnin, H.H.P., Severin, H.C. and Hartung, H.C. (1914). The ravages, life history, weights of stages, natural enemies and methods of control of melon fly. Ann. Ent. Soc. Amer. Colombia, Ohio, 7(3): 178-207.

Shimada, H., Makino, S. and Niidome, I. (1972). Control of the oriental fruit fly Dacus dorsalis Hendel, infesting mango fruits by ethylene dibromide fumigation and its effects on fruits. Proceedings of the Association for Plant Protection of Kyushu 18: 74-76.

Shivarkar, D.T. and Dumbre, R.B. (1985). Bionomics and chemical control of melon fly. J. Maharashtra Agric. Univ. 10(3): 298-300.

Singh, R.P. and Srivastava, B.G. (1985). Alcohol extract of neem Azadirachta indica Juss. seed oil on oviposition deterrent for D. cucurbitae Coq. Indian J. Entomol. 45(4): 497-498.

Shah, A.H. and Patel, R.C. (1976). Role of Tulsi plant (Ocimum sanctum) in control of mango fruit fly Dacus correctus Bezz. (Diptera : Tephritidae). Curr. Sci. 45(8): 313-314.

Shipp. E. and Osborn, A.W. (1968). Irradiation of Queensland fruit fly pupae to meet quarantine requirements. J. Econ. Entomol. 61(6): 1721-1726.

Singh, R.P. and Srivastava, B.G. (1985). Alcohol extract of neem Azadirachta indica (Juss) seed oil as oviposition deterrent for D. cucurbitae (Coq). Indian J. Entomol. 45(4): 497-498.

Sonda, M. and Ichinohe, F. (1984). Eradication of oriental fruit fly from Okinawa Island and its adjacent Islands. Japan Pesticide Information 44: 1-6.

Sreenivasan, P.M. and Narayanaswamy, P.S. (1960). Beating of the pests of bittergourd. Ind. Fmg. 10: 17.

Steiner, L.F. (1957). Fruit fly control in Hawaii with poison bait sprays containing protein hydrolysate. J. Econ. Entomol. 45: 838-843.

Steiner, L.F., Hart, W.G., Harris, E.J., Cunningham, R.T., Ohinata, K. and Kamakshi, D.C. (1970). Eradication of the oriental fruit fly from the Mariana Islands by the methods of male annihilation and sterile insect release. J. Econ. Entomol. 63(1): 131-135.

Stavrakis, G.N., Kitsos, G. Th., Mourikis, P.A. and Fytizas, E.S. (1970). Attractants for the olive fruit fly estimation of the attractiveness of certain laboratory preparations under natural condition. Ann. Inst. Phytopathol. Benaki 9(2): 94-113.

Stephen, H., Ronald, F.L., Richard, M., Dick, M. and Melvin, S. (1987). Laboratory trials of methoprene - impregnated waxes for preventing survival of adult oriental fruit flies (Diptera : Tephritidae) from infested papayas. J. Econ. Entomol. 80(2): 494-496.

Steffens, R.J. (1983). Ecology and approach to integrated control of D. frontalis on the Cape Verde Islands. In Fruit flies of economic importance. Proceedings of the CEC/IOBC International symposium, Athens, Greece, 16-19 November 1982. 632-638.

Swaine, G., Corcoran, R.J. and Davey, M.A. (1975). A commodity treatment against infestation of the Queensland fruit fly Dacus tryoni (Froggoil) in Kensington Mangoes. Queensland J. Agric. Animal Sci. 32(1): 47-50.

Syed, R.A., Ghani, M.A. and Murtaza, M. (1970). Studies on the Trypetide and their natural enemies in West Pakistan, III. Dacus (stumeta) zonatus (Saunders). Technical Bulletin, Commonwealth Institute of Biological Control (13): 1-16.

Tan, K.H. (1982). Effects of permethrin and cypermethrin against D. dorsalis in relation to temperature. Malays. Appl. Bio. 11(1): 41-45.

Tan, K.H. (1983). Response of Dacus (Diptera : Tephritidae) to Ocimum sanctum (Linn) extracts and different synthetic attractants in Penang, Malaysia. In Fruit flies of economic importance. Proceedings of the CEC/IOBC International symposium, Athens, Greece, 16-19 November 1982. 513-520.

Tan, K.H. (1984). Description of a new attractant trap and the effect of placement height on catches of two Dacus species (Diptera : Tephritidae). J. Plant Prot. Tropics 1(2): 117-120.

Teruya, T. and Zukeyama, H. (1979). Sterilization of the melon fly, D. cucurbitae Coq. with gamma radiation : effect of dose on competitiveness of irradiated males. Appl. Entomol. Zool. 14(3): 241-244.

Thakur, J.N. and Asok Kumar (1984). Effects of diflubenzuron and penfluron on the reproductive potential of the oriental fruit fly Dacus dorsalis Hendel (Diptera : Tephritidae) : Influence of age at the time of treatment on sterility. Entomon 9(1): 19-24.

Thakur, J.N. and Asok Kumar (1988). Effect of ethyl methane sulphonate (EMS) on the reproductive potential of fruit fly D. dorsalis Hendel (Diptera : Tephritidae). Entomon 13(1): 69-73.

Thompson, H.C. and Kelly, W.C. (1967). Vegetable crops. Fifth edition. Mc Graw-Hill Book Company, New York.

Thomas, P. and Rahalkar, G.W. (1975). Disinfestation of fruit flies in mango by gamma radiation. Curr. Sci. 44(21): 775-776.

Tzanatakis, M.E. (1972). Current status and prospects of applying the sterile-insect release method against D. oleae. Proceedings of a panel on the practical use of the sterile male technique for insect control organised by the Joint FAO/IAEA. Division of Atomic Energy in Food and Agriculture held in Vienna, 13-17 November 1972. 109-115.

Vita, G., Urio, U., Fedeli, E. and Jacini, G. (1977). The use of natural substance present in olives as a prospective control measure against D. oleae (Gmel). Boll. Lab. Ent. Agra. Filoppa. Silvestn Portici. 34: 55-61.

Vita, G., Ross, R. and Carpita, A. (1980). Field evaluation of the attractiveness to D. oleae (Gmel) exerted by ammonia-releasing chemical formulations. Redia 63: 185-196.

Voaden, D.J., Schwarz, M., Waters, R.M., Jacobson, M. and Keiser, I. (1984). Synthesis and biological evaluation of candidate nonenyl acetates on melon fly ovipositional attractants. J. Agric. Food Chem. 32(4): 769-773.

Wen, H.C. (1985). Field studies on melon fly, Dacus cucurbitae and attractants experiments in Southern Taiwan. J. Agric. Res. China 34(2): 228-235.

Wesley, W.K. (1956). Major insect pests of vegetables in Allahabad. Allahabad Fmr. 30(4): 136-137.

Zervas, G.H. (1982). A new long life trap for olive fruit fly Dacus oleae (Gmelin) (Diptera : Tephritidae) and other Dipetera. Z. Argen. Entomol. 94(5): 522-539.

* Original not seen

Appendices

APPENDIX I

Data relating to Table 5

Treatments		Mean number of fruits obtained in harvest done at				
		8th WAP	9th WAP	10th WAP	11th WAP	12th WAP
LGW		21.33	23.33	24.00	17.00	19.00
LG		23.67	27.33	15.00	11.33	17.33
Priya		41.33	55.33	47.67	30.00	37.67
NBPGR	6	20.62	38.00	4.00	2.00	6.33
,,	7	34.67	48.33	42.00	26.33	34.33
,,	17B	53.00	58.00	5.00	5.33	12.67
,,	19	34.00	47.67	47.00	31.66	36.67
,,	35	25.67	36.00	54.00	28.33	28.67
,,	80	42.00	56.00	54.00	35.66	38.67
,,	83	32.67	40.00	27.33	19.00	26.67
,,	239	30.00	37.33	27.00	20.00	29.00
,,	244	27.67	45.33	65.33	38.67	33.00
,,	261	47.00	58.67	64.67	44.67	34.33
,,	271	18.00	22.33	27.67	18.00	23.00

WAP : weeks after planting
LGW : local greenish white
LG : local green
NBPGR : National Bureau of Plant Genetic Resources

APPENDIX II

Data relating to Table 6

Treatments	Mean weight of fruits obtained in harvest done at				
	8 WAP	9 WAP	10 WAP	11 WAP	12 WAP
LGW	673.33	1460.00	1366.67	766.67	366.67
LG	666.67	1246.67	733.33	933.33	366.67
Priya	1100.00	2780.00	2700.00	1400.00	900.00
NBPGR 6	453.33	1653.33	2200.00	1400.00	600.00
,, 7	1153.33	2846.67	2066.67	866.67	980.00
,, 17B	2160.00	3546.67	2466.67	1133.33	1133.33
,, 19	846.67	2066.67	1966.67	966.67	900.00
,, 35	706.67	1840.00	2200.00	1366.67	600.00
,, 80	1113.33	2306.67	2166.67	1200.00	933.33
,, 83	1253.33	2086.67	1333.33	1266.67	766.67
,, 239	840.00	1766.67	1966.67	2033.33	750.00
,, 244	180.00	960.00	1300.00	1033.33	383.33
,, 261	593.33	1753.33	2000.00	1033.33	1033.33
,, 271	693.33	1293.33	1433.37	1133.33	633.33

WAP : weeks after planting

LGW : local greenish white

LG : local green

NBPGR : National Bureau of Plant Genetic Resources

INTEGRATED CONTROL OF FRUIT FLY
***Dacus cucurbitae* Coq:**
TRYPETIDAE: DIPTERA ON BITTER GOURD

BY

JALAJA, P. N.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement
for the degree

Master of Science of Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Entomology
COLLEGE OF AGRICULTURE
Vellayani, Trivandrum
1989

ABSTRACT

Bittergourd is very popular among the vegetable growers in Kerala. Fruit flies take a heavy toll of this crop and intense use of pesticides is a common practice of cultivators often leading to serious residue hazards in the marketed fruits. In the present investigation an attempt was made to standardise non-insecticidal methods of control for tackling this pest problem.

Laboratory evaluation of potential attractants of fruit flies viz. eugenol, eucalyptus oil, citronella oil, borax, ammonium phosphate, vanilla essence, jaggery, sugar, vinegar, honey, toddy and bittergourd fruits were screened for baiting the adults of *D. cucurbitae*. Eugenol, eucalyptus oil, citronella oil, borax, ammonium phosphate and vanilla essence did not show any attractiveness to the flies. Three graded concentrations of honey, sugar, jaggery, toddy and vinegar were tested for their attractiveness to the flies in the laboratory. The result showed that (1) honey at the highest concentration of 1% attracted the maximum number of flies, (2) toddy was not effective for attracting *D. cucurbitae*, (3) immature stages of bittergourd fruits showed poor attraction and (4) ripe bittergourd fruits showed maximum attraction to the flies up to 12 h of exposure.

Field evaluation of the attractants showed that one per cent honey was significantly superior to all other treatments. Toddy had a better performance in the field than in the laboratory. Vinegar which failed to show significant attractiveness to the flies in the laboratory was found effective as a bait in field evaluation.

Evaluation of different banana varieties (nendran, poovan, palayankodan and rasakadali) taking honey as standard, conducted in the field showed that honey one per cent, palayankodan and poovan varieties of banana fruits came on par.

Forty seven accessions of bittergourd grown at NBPGR, Vellanikkara were screened and the result showed that none of the accessions was highly resistant to the flies. Fourteen accessions of bittergourd were screened and the result showed that accessions 17B and 6, found resistant in the initial screening became moderately resistant in the replicated field experiment. Accession 35 which was in the moderately resistant group in the initial screening came in the resistant group in the replicated trial. The accessions 239 and 244 were found more resistant than accession 35.

Laboratory observation on the infested fruits collected from different varieties revealed that the relatively resistant

NBPGR accessions 239, 244 and 35 did not show any antibiosis towards *D. cucurbitae* when compared with the check variety Priya.

Evaluation of different materials for caging the developing bittergourd fruits for the control of fruit fly damage showed that paper bags and cloth bags did not completely protect the fruits from egg laying by the flies. The fruits covered with polythene bags gave complete protection from egg laying.

Bagging the developing fruits with polythene bags for varying periods from fruit set showed that fruits protected up to eight days were completely free from the attack by the flies.

The effect of bagging the developing fruits, trapping the fruit flies and combination of both, in comparison with the current practices of spraying the crop at weekly intervals after fruit set, showed that best yield was obtained from plots in which the fruits were bagged and trapping of adults were done.